

Revised Draft

DHS Policy Memorandum
97-005 Documentation
Raymond Basin, Monk Hill Subarea

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Acronyms

ACM	asbestos-containing materials
AL	action level
AOT	advanced oxidation treatment
ASTM	American Society of Testing Materials
AT123D	Analytical Transient 1-, 2-, 3-Dimensional Model
AWWARF	American Water Works Association Research Foundation
bgs	below ground surface
BOD	biological oxygen demand
CCR	California Code of Regulations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	cubic feet per minute
CFU	colony forming units
CHMIRS	California Hazardous Material Incident Report System
COPC	chemical of potential concern
CRP	Community Relations Plan
DCA	dichloroethane
DCE	dichloroethene
DHS	(California) Department of Health Services
DTSC	(California) Department of Toxic Substances Control
DWSAP	Drinking Water Source Assessment Protection
EDR	Environmental Data Resources
EE/CA	Engineering Evaluation/Cost Analysis
EPA	(United States) Environmental Protection Agency
ERNS	Emergency Response Notification System
FBR	fluidized bed reactor
FFA	Federal Facility Agreement
FMWD	Foothill Municipal Water District
FS	Feasibility Study
FTU	Fixed Treatment Unit
FWEC	Foster Wheeler Environmental Corporation
GAC	granular activated carbon
gpm	gallon per minute
HAZNET	(California) Hazardous Waste Information System
HI	hazard index
HMX	high-velocity military explosive
HPC	heterotrophic plate count

HQ	hazard quotient
JPL	Jet Propulsion Laboratory
LAWC	Lincoln Avenue Water Company
LF	Landfill Facility
LGAC	liquid-phase granular activated carbon
LIA	Local Implementing Agency
LQG	large quantity generator
LUST	leaking underground storage tank
MCL	maximum contaminant level
MSW	municipal solid waste
MTBE	methyl- <i>tert</i> -butyl ether
MWD	Metropolitan Water District
NARA	National Archives and Records Administration
NASA	National Aeronautics and Space Administration
NDMA	<i>n</i> -nitrosodimethylamine
NPL	National Priorities List
NSF	National Sanitation Foundation
O&M	operations and maintenance
OEHHA	(California) Office of Environmental Health Hazard Assessment
OU	Operable Unit
PA/SI	preliminary assessment/site inspection
PCE	tetrachloroethene
PHG	public health goal
ppb	parts per billion
ppt	parts per trillion
PQL	practical quantitation limit
PRG	Preliminary Remediation Goal
POTW	publicly owned treatment works
PWP	Pasadena Water and Power
RBMB	Regional Basin Management Board
RCRIS	Resource Conservation and Recovery Information System
RDX	royal demolition explosive
RI	Remedial Investigation
ROD	Record of Decision
RWQC	Raw Water Quality Characterization
RWQCB	Regional Water Quality Control Board, Los Angeles Region
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SCADA	Supervisory Control and Data Acquisition

SCAQMD	South Coast Air Quality Management District
SQG	small quantity generator
SWA	Source Water Assessment
SWF	Solid Waste Facility
SWRCB	State Water Resources Control Board
SVE	soil vapor extraction
TCE	trichloroethene
TCP	trichloropropane
TIC	tentatively identified compound
TNT	2,4,6-trinitrotoluene
TPH-D	total petroleum hydrocarbons quantified as diesel
TPH-MO	total petroleum hydrocarbons quantified as motor oil
TTU	Transportable Treatment Unit
USGS	United States Geological Survey
UST	underground storage tank
VGAC	vapor-phase, granular activated carbon
VOC	volatile organic compound
WDS	waste discharge system

1.0 Introduction

The National Aeronautics and Space Administration (NASA) is responsible for remediation of chemicals originating from the Jet Propulsion Laboratory (JPL) site, as required under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This cleanup effort includes treatment of groundwater extracted from drinking water production wells containing site-related chemicals of interest, which include volatile organic compounds (VOCs) and perchlorate. NASA is evaluating treatment requirements at nine drinking water production wells in the Monk Hill Subarea of the Raymond Basin: the Arroyo Well, Well 52, the Ventura Well, and the Windsor Well operated by Pasadena Water and Power (PWP); Wells #3 and #5 operated by the Lincoln Avenue Water Company (LAWC); Wells #4 and #7 operated by the Rubio Cañon Land and Water Association; and Well #2 operated by the Las Flores Water Company. Figure 1-1 shows the location of these production wells.

Because the source water for these nine wells meets the criteria of an “extremely impaired source” as defined in California’s Department of Health Services (DHS) Policy Memorandum 97-005, this document has been prepared as part of the domestic water supply permitting process. A copy of the DHS Policy Memorandum is provided in Appendix A.

This report is organized into eight sections. Section 1.0 includes this introduction. Section 2.0 provides the source water assessment (SWA). Section 3.0 is the full characterization of the raw water quality and Section 4.0 identifies existing source protection programs. Section 5.0 describes the effective monitoring and treatment. Section 6.0 estimates the risks associated with the failure of the treatment system and Section 7.0 identifies the alternatives and associated risks. Section 8.0 lists the references cited throughout the report.

1.1 Description of Source Water

The source water evaluated in this document is the groundwater contained within the capture zones of the production wells. These production wells are located in the Monk Hill Subarea of the Raymond Basin and downgradient of the JPL facility. Table 1-1 provides summary information for eight of the nine production wells based on well construction logs and well data sheets from the Drinking Water Source Assessment Protection (DWSAP) Program. Figures 1-2 through 1-7 are well construction diagrams or boring logs for each production well with the exception of LAWC #3 and #5 wells and Rubio Cañon Well #7. For the LAWC wells, construction details were obtained from DWSAP well data sheets because boring logs could not be located. Construction details for the Rubio Cañon Well #7 are unknown because boring logs, well schematics, or DWSAP well data sheets could not be located.

1.2 Applicability of DHS Policy Memorandum 97-005 to the Production Wells

DHS considers the Monk Hill Subarea to be an extremely impaired source because it contains a constituent that exceeds 10 times an action level (AL) based on chronic health effects, it is in close proximity to a CERCLA site, and it contains a mixture of chemicals of health concern. The rationale for the identification of these criteria is provided as follows:

- ❑ The maximum detected perchlorate concentration of 160 µg/L from the Arroyo Well exceeds 10 times the current AL of 6 µg/L for perchlorate; this AL is based on chronic health effects which assumes an intake of 2 L of drinking water per day.
- ❑ All of the production wells are located southeast of the JPL facility. This facility was placed on the United States Environmental Protection Agency (EPA) National Priorities List (NPL) in 1992. The groundwater extracted by the production wells are part of Operable Unit-3 (OU-3), off-facility groundwater.
- ❑ Carbon tetrachloride, trichloroethene (TCE), tetrachloroethene (PCE), 1,2,3-trichloropropane, (1,2,3-TCP), and perchlorate are chemicals of potential health concern that have been detected in groundwater samples collected from the Monk Hill Subarea.

2.0 Source Water Assessment

Source water is defined as the groundwater contained within the capture zones of production wells. The purpose of this SWA is to evaluate the vulnerability of the groundwater extracted from the Monk Hill production wells to releases of chemicals in the subsurface environment. The SWA describes how the capture zones for the production wells were established and identifies known and potential chemical sources. Source identification was conducted in accordance with DHS Policy Memorandum 97-005 by evaluating the following:

- ❑ The origin of identified chemicals in the groundwater and prediction of future chemical level trends;
- ❑ Chemicals used at or generated by facilities responsible for chemicals known to be in groundwater; and
- ❑ Other potential sources and determination of the vulnerability of the groundwater to these other sources.

2.1 Delineation of Source Water Capture Zones

The capture zones for the production wells encompass the areas within the aquifer that are hydraulically influenced when these production wells are in use. The capture zones are used to assess which portions of the aquifer (both laterally and vertically) contribute water extracted from the production wells.

Section 2.1.1 provides a description of the geology and hydrogeology within the capture zones, and Sections 2.1.2 and 2.1.3 describe the methodology and identification of the capture zones.

2.1.1 Geology and Hydrogeology

2.1.1.1 Geologic Setting

The San Gabriel Valley is divided into distinct groundwater basins. The Raymond Basin, where the production wells are located, is bordered on the north by the San Gabriel Mountains, on the west by the San Rafael Hills, and on the south and east by the Raymond Fault. The Raymond Basin is further divided into three subareas as shown on Figure 2-1: the Pasadena Subbasin, the Santa Anita Subbasin, and the Monk Hill Subarea. All nine production wells under discussion in this document are located in the Monk Hill Subarea, which provides potable groundwater for several communities in the area including Pasadena, La Cañada-Flintridge, and Altadena (Foster Wheeler Environmental Corporation [FWEC], 2000).

2.1.1.2 Hydrogeologic Setting

In the Raymond Basin, a confluence of groundwater flow regimes occurs within the Monk Hill Subarea. Within the western portion of the Monk Hill Subarea the groundwater flow is predominantly to the southeast, and at the eastern portion of the Monk Hill Subarea the groundwater flow is predominantly to the south. However, the presence and operation of

groundwater recharge basins (spreading grounds) in the Arroyo Seco and municipal groundwater production wells locally influence groundwater flow directions.

The Monk Hill Subarea is generally considered to be an unconfined aquifer. However, vertical hydraulic head (water level) differences with depth are observed between well screens in deep multi-level monitoring wells located near the production wells. The head differences are caused by the presence of relatively thin, silt-rich layers located throughout the alluvial aquifer that inhibit vertical flow of groundwater (FWEC, 1999a). These data indicate that the aquifer does not exhibit unconfined conditions. Therefore, the aquifer can be divided into four groundwater modeling unit layers, based primarily on how these silt-rich intervals influence the hydraulic heads in the aquifer during pumping of the nearby municipal wells. Throughout this document, these layers are interchangeably referred to as modeling unit layers or aquifer layers. These layers are discussed in further detail in the following paragraphs and in subsequent sections.

A surface geologic map of the study area produced by the California Division of Mines and Geology and five geologic cross sections are provided in Figures 2-2 and 2-3. The cross sections were constructed by correlating lithologic logs, geophysical logs, and water-level and hydraulic-head data from the deep JPL multiport monitoring wells. The geologic formations and cross sections present within the study area are included in Figure 2-2.

The lithologic columns and geophysical logs depicted on the cross sections represent the boring logs and geophysical logs obtained during the Remedial Investigation (RI) for Operable Unit-1 (OU-1) and OU-3 (FWEC, 1999a). The correlation between wells was complicated by the variable nature of alluvial fan-type deposits present at JPL. Correlation between wells of generally similar lithologic sequences at similar depths was made whenever possible, as opposed to attempting to correlate individual sand and silt layers. Correlation between wells also was made between sections of the aquifer that had similar responses to pumping of nearby municipal production wells (similar amounts of drawdown). Historical hydrographs from JPL monitoring wells are included on the cross sections (Figure 2-3) for reference.

Based on this approach, four primary aquifer layers were delineated for the study area above the crystalline basement complex. The primary aquifer layers present in the study area were identified based on geologic formations published by the California Division of Mines and Geology and the United States Geological Survey (USGS). The four aquifer layers in the study area include the upper and lower sections of the Older Franciscan Series (Aquifer Layers 1 and 2, respectively), the Pacoima Formation (Aquifer Layer 3), and the Saugus Formation (Aquifer Layer 4). Although Layer 4 is part of the aquifer, it is not present beneath the area of interest and is therefore not discussed further in this report (NASA, 2004).

Groundwater elevation measurements have been recorded routinely to characterize aquifer conditions as part of the CERCLA program at JPL. Water-table elevations in JPL monitoring wells located at the mouth of the Arroyo Seco (MW-1, MW-9, and MW-15) have been consistently higher than water-table elevations in other JPL monitoring wells, indicating the presence of a significant groundwater mound. This mound is typically between 80 and 120 ft higher than the surrounding water table and is a result of recharge from the mouth of the Arroyo Seco, and possibly the presence of unmapped low-permeability physical barriers (FWEC, 1999a).

The groundwater surface has been measured in the JPL monitoring wells at depths ranging from approximately 22 ft to 270 ft below ground surface (bgs). This wide range of depths to groundwater can primarily be attributed to the relatively steep topography present in the area and local groundwater mounding at the mouth of the Arroyo Seco. It also can be attributed to seasonal groundwater recharge from nearby spreading grounds and the extraction of groundwater from nearby municipal production wells (FWEC, 2000).

2.1.1.3 Groundwater Flow Conditions

The groundwater flow conditions near the production wells are affected by various natural and anthropogenic influences that include the following: (1) pumping from other nearby municipal production wells, (2) groundwater recharge from Arroyo Seco spreading basins, (3) seasonal and regional groundwater recharge from precipitation, and (4) regional groundwater flow.

Potentiometric surface maps that represent groundwater flow conditions during non-operational and operational periods of nearby production wells (14 production wells and 2 aquifer storage and recovery wells) are shown in Figures 2-4 and 2-5, respectively. The February 1996 data are the most appropriate for the potentiometric surface maps associated with operational periods because more recent data do not exist since Arroyo well was shut down in 1997. Pumping rates have been included in Figure 2-5. Please refer to the Groundwater Modeling Report (NASA, 2004) for specific detail regarding pumping rates and production well usage. More recent data (February 9, 2004) were used to create potentiometric surface maps for Aquifer Layers 1, 2, and 3 for nonoperational periods. Historical groundwater elevations in Layers 1, 2, and 3 are illustrated in Figures 2-6, 2-7, and 2-8, respectively. These figures also show the correlation between changes in the groundwater elevations measured in multi-level monitoring wells during operational cycles of the nearby municipal production wells.

Groundwater flow in the capture zones is primarily to the southeast. However, changes in the groundwater flow direction may occur temporarily during periods of high recharge at the Arroyo Seco spreading basins (typically between the months of January and March), combined with the non-operation of City of Pasadena wells. During these times, the groundwater mound at the mouth of the Arroyo Seco apparently expands locally, changing the groundwater gradient to the west across parts of the area where the Arroyo Well and Well 52 capture zones are located. A study found that localized groundwater gradient (water-table) changes were observed each year with durations ranging from approximately 9 days to 16 weeks (FWEC, 1999a). These shallow aquifer gradient changes are localized and the duration of the changes primarily depends on pumping schedules of City of Pasadena wells, precipitation, and rates of groundwater recharge in the Arroyo Seco spreading basins (FWEC, 2000).

2.1.2 Methodology for Delineation of Capture Zones

The capture zone areas for the Monk Hill production wells are depicted in Figures 2-9 through 2-12. Also depicted on Figures 2-9 through 2-12 is the zone of capture that will result when the proposed OU-1 on-facility treatment system is implemented. The 250 gpm OU-1 treatment system is designed to treat VOCs and perchlorate using liquid-phase granular activated carbon (LGAC) and a fluidized bed reactor (FBR), and the treated water will be reinjected into the subsurface (NASA, 2003b). As shown on Figures 2-9 and 2-10, the proposed on-facility system

is designed to capture a significant portion of the groundwater in the upper portions of the aquifer directly beneath JPL, the area with the highest chemical concentrations (i.e., source area). Delineation of the source water capture zones for the production wells was determined using a three-dimensional finite element groundwater flow model developed by NASA (2004). The groundwater model encompasses a 4,560-acre area that includes the Monk Hill portion of the Raymond Basin. The model consists of four elemental layers that are bounded by five nodal slices. The extent of the model domain and the calibrated material properties for each of the four layers is discussed in detail in the *JPL Groundwater Modeling Report* (NASA, 2004).

2.1.3 Identification of Capture Zones

The capture zones for each production well were identified using a steady-state flow simulation to generate the groundwater flow fields. Forward and backward particle-tracking was used to assess the advective flow paths of the groundwater. After review of the particle-tracking results, capture zones were developed for the production wells. Because a significant vertical component to groundwater flow is present in the study area (particularly near the production wells and spreading basins), capture zones were developed for the different modeling unit layers represented in the model as Model Layers 1 through 4.

Extraction rates for the production wells were based on anticipated treatment system operation for the PWP wells (Arroyo, Well 52, Ventura, and Windsor) and pumping rate data from January 2000 through January 2003 obtained from the Raymond Basin Management Board (RBMB) Database (Geoscience, 2004). For the PWP wells, it is anticipated that there will be one treatment system installed capable of treating 7,000 gpm. However, operation of the system at 7,000 gpm will only occur for 5 months per year. For the other 7 months, groundwater pumping will be from the Arroyo and Well 52 at variable flow rates between 1,800 to 4,000 gpm. For the other production wells, pumping data were reviewed for the stated time period and determinations were made for high and low rates and the number of months for when these rates were in use throughout the year were identified. Table 2-1 summarizes the extraction rates and months pumped for each of the production wells include in the capture zone analysis.

Because the capture zone analysis was conducted using a steady-state flow simulation, a time-weighted averaging approach was used to account for the different rates used throughout the months in the year. Time-weighted averages shown on Table 2-1 were derived by summing the products of the high average multiplied by number of months pumped and the low average multiplied by number of months pumped and then dividing by 12 months.

The composite capture zones also are based on these assumptions:

- ❑ Groundwater flow is steady-state based on average groundwater flow conditions from 1996 to 2000;
- ❑ All of the Monk Hill production wells are in use, including the Valley Water Company wells and La Cañada Irrigation District wells;
- ❑ The capture zone is a two-dimensional representation of a three-dimensional groundwater flow system in the study area.

The capture zone analysis is subject to uncertainties associated with the groundwater flow parameters as detailed in the *JPL Groundwater Modeling Report* (NASA, 2004).

2.2 Origin of Known Chemicals in the Source Water and Prediction of Concentration Trends

2.2.1 Jet Propulsion Laboratory Facility

JPL is located on a 176-acre site in the foothills of the San Gabriel Mountains at 4800 Oak Grove Drive, approximately 12 miles northeast of Los Angeles. JPL is located in Los Angeles County, connecting La Cañada-Flintridge and the City of Pasadena and bordered on the east by the unincorporated community of Altadena. Geographically, JPL is located at latitude 34.201°N and longitude 118.173°W (USGS topographic map, Pasadena quadrangle).

JPL is situated on a south-facing slope along the southern base of the east-west trending San Gabriel Mountains located on the northern edge of the Los Angeles metropolitan area. The Arroyo Seco, an intermittent streambed, lies immediately to the east and southeast of the site. Within the Arroyo Seco is a series of surface impoundments used to collect surface water runoff during the rainy season for groundwater recharge. Residential development, an equestrian club (Flintridge Riding Club), and a Los Angeles County Fire Department Station border the site along its western, southwestern, and southern boundaries, respectively. Residential development also is present to the east of the JPL facility, along the eastern edge of the Arroyo Seco.

Various chemicals and materials have been used during the operational history of the JPL facility. The general types of materials used and produced include a variety of solvents, solid and liquid rocket fuel propellants, cooling-tower chemicals, and analytical laboratory chemicals. Many buildings at JPL used seepage pits during the 1940s and 1950s to dispose of liquid and solid materials via infiltration into surrounding soil (Figure 2-13). Some of these seepage pits may have received halogenated solvents, solid fuel residue containing perchlorate, and other chemicals that currently are found in the groundwater. In the late 1950s and early 1960s, a sewer system was installed at JPL, and the use of seepage pits for waste disposal was discontinued.

In 1988, as part of the CERCLA process, a preliminary assessment/site inspection (PA/SI) was completed for groundwater, indicating that further site characterization was necessary (Ebasco Environmental, 1988). In 1990, an expanded site inspection was performed in which several groundwater monitoring wells were installed (Ebasco Environmental, 1990a). VOCs subsequently were detected at concentrations above drinking water standards during the expanded site inspection. Currently 10 single zone and 13 multi-zone groundwater monitoring wells are installed within and surrounding the JPL facility which make up the JPL monitoring well network. Groundwater monitoring of these wells was initiated following the expanded site inspection and is currently ongoing. For additional information regarding the site characterization and the nature and extent of chemicals in groundwater, refer to the RI report (FWEC, 1999a).

2.2.2 Upgradient Groundwater

The Valley Water Company wells are located to the west/northwest of the JPL facility and are considered upgradient wells. A review of basin hydrographs included in historical Watermaster reports (since 1950) support a south/southwest regional flow between the Valley Water Company wells and JPL. The subsurface topography of the basin (i.e., bedrock surface) also supports a south/southwest regional groundwater flow direction. A summary of constituents detected in the Valley Water Company Wells #1, #2, #3, and #4 is provided on Table 2-2. These data indicate that 15 of the 41 chemicals detected in the Valley Water Company wells were VOCs. Two of these VOCs, TCE and PCE, were detected frequently (i.e., 95% and 70% of the samples, respectively). Carbon tetrachloride was only detected once out of 195 samples. Additionally, perchlorate and naturally occurring constituents, including metals and radionuclides, were detected in these wells.

2.2.3 Chemicals Detected in the JPL Monitoring Wells

Chemicals that potentially could be in groundwater within the capture zones of the production wells were identified by reviewing historical and recent groundwater monitoring data for the JPL monitoring wells. The groundwater data review included water quality data from monitoring wells sampled from September 1992 through November 2003. A summary of the chemicals detected in groundwater samples collected from the JPL monitoring well network is provided in Table 2-3. In addition, NASA conducted a comprehensive groundwater monitoring event at JPL in December 2002 and January 2003, for select wells located within the production well capture zones. This event was conducted to provide supplemental water quality data based on the analyses required in DHS Policy Memorandum 97-005.

2.2.3.1 Historical Groundwater Monitoring Data

A review of historical groundwater monitoring data was conducted for wells sampled from 1992 through 2003. The locations of JPL monitoring wells are shown on Figure 1-1. Groundwater sampling occurred at least twice a year from 1992 to February 1998; 15 sampling events occurred during this time. Sampling from May 1998 through 2003 is part of the Long-Term Quarterly Groundwater Monitoring Program that is still ongoing for the JPL monitoring wells.

The Long-Term Quarterly Groundwater Monitoring Program includes analyses for VOCs, perchlorate, metals, *n*-nitrosodimethylamine (NDMA), 1,4-dioxane, general minerals, and field parameters. The analyses for inorganics, metals, anions, cations, alkalinity, and pH have recently been performed annually. Perchlorate, carbon tetrachloride, TCE, PCE, and 1,2-dichloroethane (1,2-DCA) are specifically monitored because these chemicals have been previously detected in groundwater at concentrations exceeding state or federal maximum contaminant levels (MCLs) or ALs (FWEC, 1999a). A list of the current analyses and frequencies for the JPL CERCLA monitoring program is provided as follows:

- VOCs: quarterly or semi-annually for all wells
- Perchlorate: quarterly or semi-annually for all wells
- Total Chromium: quarterly or semi-annually for select wells

- ❑ Hexavalent Chromium: quarterly or semi-annually for select wells
- ❑ Lead: annually, all wells
- ❑ Arsenic: annually, all wells
- ❑ NDMA: annually, select wells
- ❑ 1,4-Dioxane: annually, select wells
- ❑ Title 22 General Minerals: annually, all wells.

A summary of all of the analyses conducted and data obtained through October/November 2003 from the JPL monitoring wells is presented in Table B-1 of Appendix B. In addition, a condensed summary of VOC and perchlorate data for all wells is provided in Table B-2 of Appendix B. A total of 204 parameters have been analyzed for in JPL wells (Table B-1). Table 2-3, which only summarizes the analytes detected in JPL wells, indicates that 93 chemicals have been detected at least once. Therefore, 111 chemicals have been analyzed for but have not been detected (Appendix B, Table B-1).

Some of the chemicals detected are naturally occurring, including metals (aluminum, arsenic, barium, boron, calcium, chromium, iron, lead, magnesium, mercury, molybdenum, nickel, potassium, selenium, sodium, strontium, thallium, vanadium, and zinc) and radiological parameters (gross alpha, gross beta, radium 226, and radium 228). Concentrations of these naturally occurring constituents are evaluated in Section 3.0 with respect to regional background conditions and/or upgradient levels.

The RI for the groundwater OUs was completed in 1999, which characterized the nature and extent of chemicals of potential concern in groundwater (FWEC, 1999a). From this extensive RI investigation, only five constituents were identified as being present above drinking water standards or interim action levels. These include three VOCs (carbon tetrachloride, TCE, and 1,2-DCA); and perchlorate and chromium (both total and hexavalent). Of these, 1,2-DCA was detected on-site only, at levels slightly exceeding the state and federal MCL (0.5 µg/L). Chromium has been frequently detected only in two on-site wells, with very rare, sporadic detects at very low levels in few off-site wells. Only carbon tetrachloride, TCE, and perchlorate have been detected at levels exceeding state and federal drinking water standards or action levels in monitoring wells both on-site and off-site (FWEC, 1999a). Concentration contours for perchlorate, carbon tetrachloride, and TCE in three of the modeling layer units for January/February 2003 data have been provided in Figures 2-14 through 2-22 to provide a representation of concentrations and distribution of the chemicals in the upper three aquifer layers.

2.2.3.2 Comprehensive Groundwater Monitoring Event at JPL

Results of the comprehensive groundwater monitoring event conducted at JPL were used to provide supplemental water quality data from JPL monitoring wells in order to provide the detailed water quality characterization (Section 3.0). A *Draft Sampling and Analysis Plan (SAP), Comprehensive Groundwater Monitoring Event for DHS Policy Memo 97-005 Permit Application* (CH2M Hill, 2002) was prepared to support the field and laboratory activities associated with the sampling event. Section 3.0 of this report contains specific details regarding monitoring well selection and the derivation of the analytical parameters for this monitoring event.

The JPL monitoring wells (e.g., MW-3) and multi-level well screens (e.g., MW-3-3 refers to monitoring well 3 – screen 3) selected for the comprehensive groundwater monitoring event included: MW-3-3, MW-3-5, MW-4-1, MW-4-2, MW-4-5, MW-7, MW-8, MW-10, MW-12-3, MW-12-5, MW-14-2, MW-14-4, MW-16, MW-17-3, MW-17-4, MW-18-3, MW-18-4, MW-19-3, MW-19-5, MW-21-3, MW-21-5, MW-24-2 (see Figure 2-23). DHS participated in the selection of the wells and analytical methods, and in November 2002 approved all of the analyses contained on Table 2-4. Constituents detected in monitoring wells sampled during the comprehensive groundwater monitoring event are summarized in Table 2-5. Out of 388 constituents analyzed for, only 69 were detected at least once. Constituents (excluding general physical/chemical parameters) detected in the comprehensive monitoring event that were not detected (or not analyzed for) in the historical JPL monitoring data include 2,4,6-trinitrotoluene (TNT), high-velocity military explosive (HMX); and royal demolition explosive (RDX); *n*-nitrosodiphenylamine; chlorate; total petroleum hydrocarbons quantified as diesel (TPH-D); TPH-motor oil (TPH-MO); beryllium; boron; bromide; chlorate; cobalt; manganese; propachlor; silver; and vanadium. Additional detail regarding the sampling and analyses and the results of the comprehensive groundwater monitoring event are provided in Section 3.0.

2.2.4 Concentration Trends

Carbon tetrachloride concentrations in the Monk Hill Subarea are believed to originate primarily from JPL. Perchlorate and TCE concentrations in the Monk Hill Subarea appear to originate from JPL, but also are present in upgradient water. The primary source of PCE in the Monk Hill Subarea appears to be upgradient of JPL. A summary of perchlorate and VOC (i.e., TCE, PCE, and carbon tetrachloride) concentrations in groundwater from the JPL monitoring wells for data from 1996 to 2003 is presented in Table B-2 in Appendix B. Concentration trends for the perchlorate and the specific VOCs are provided here because they have been identified as site-related constituents for JPL that also have been detected in production wells downgradient of JPL. Trends in JPL wells can be used to estimate future trends in areas downgradient of these wells.

The concentration trends for nine JPL monitoring wells (MW-7, MW-16, MW-24, MW-4, MW-3, MW-18, MW-19, MW-20, and MW-21) are shown in Figures 2-24 through 2-32, respectively. These wells were chosen for their concentration trends because of their location with respect to the capture zone analysis and/or as a result of having relatively high concentrations of perchlorate or the VOCs. For instance, MW-7, MW-16, and MW-24 have the highest historical concentrations of VOCs and perchlorate; MW-3 and MW-4 are located nearest the Arroyo Well and Well 52 (see Figure 2-23), just to the northwest of these production wells. Monitoring wells MW-19 and MW-21 are located off-site in areas considered upgradient of the City of Pasadena production wells, but within the capture zones of the Ventura and Windsor wells (Figures 2-9 through 2-12). Monitoring wells MW-18 and MW-20 are located off-site, but within the capture zones of the Lincoln Avenue and Rubio Cañon production wells (Figures 2-9 through 2-12).

MW-7

Concentrations of TCE in MW-7 have decreased between 1996 and 2003 (monitoring period), but PCE, carbon tetrachloride, and perchlorate concentrations have increased during this period (Figure 2-24).

MW-16

Concentrations of TCE, PCE, and carbon tetrachloride have decreased over time in MW-16 (Layer 1 in the aquifer), but perchlorate concentrations have generally increased since November 1999 (Figure 2-25).

MW-24

In Screen 1 (Layer 1 in the aquifer) of MW-24, concentrations of PCE, carbon tetrachloride, and perchlorate exhibit an overall increasing trend, whereas TCE concentrations continue to fluctuate as a result of seasonal effects (Figure 2-26). In Screen 2 of MW-24 (Layer 2 in the aquifer) concentrations of perchlorate, carbon tetrachloride, TCE, and PCE have been generally decreasing (Figure 2-26).

MW-4

Concentrations of TCE, carbon tetrachloride, and perchlorate have generally decreased over time in Screen 2 (Layer 2 in the aquifer) of MW-4, whereas PCE concentrations have increased, but still remain below the CA MCL (Figure 2-27).

MW-3

In Screen 3 (Layer 2 in the aquifer) of MW-3, concentrations of TCE and PCE have remained below the MCLs, but carbon tetrachloride and perchlorate have had sporadic exceedances of the MCL and AL, respectively, prior to May 2002. Concentrations for both these constituents have been at or below the drinking water standards since May 2002 (Figure 2-28).

MW-18

Concentrations of carbon tetrachloride, TCE, and PCE were relatively low and consistent up until April 2002 when there was a sharp increase (Figure 2-29). Concentrations of the VOCs steadily declined and by the following year were at concentrations similar to pre-April 2002. Perchlorate concentrations fluctuated over time, but exhibit an overall increasing trend.

MW-19

Concentrations of carbon tetrachloride have been steadily below the MCL since 1996 (Figure 2-30). Concentrations for perchlorate, TCE, and PCE fluctuate throughout the years, but have remained below the AL or MCL since late 1999.

MW-20

Concentrations of VOCs in MW-20 have never been detected above the MCL in either Screen 1 or Screen 4 and reached a maximum concentration of 124 µg/L in April 2003 (Figure 2-31). Perchlorate, however, has demonstrated an increasing trend since April 2002 in the deeper screen (Screen 4). Concentrations of perchlorate in Screen 1 have fluctuated around the AL of 6 µg/L since sampling of this well began.

MW-21

Concentrations of carbon tetrachloride have been nondetect in MW-21 (Figure 2-32). Concentrations of TCE have fluctuated throughout the years, but have remained below the MCL. Similarly, perchlorate concentrations have varied over the years, but remain below the AL. TCE concentrations in Screen 3 varied over time, but remained below the MCL. Concentrations of TCE in Screen 4, however, show an increasing trend and have exceeded the AL.

Based on these data, predicting concentrations of chemicals in the source water would be difficult. However, future concentrations at JPL wells are expected to be decreasing because

NASA is actively engaged in cleanup of on-facility soil (OU-2) and on-facility groundwater (OU-1). Cleanup activities are discussed in Section 4.2.

2.3 Identification of Chemicals Used at or Generated by Facilities Responsible for Chemicals Known to be in Source Water

An assessment was conducted to identify chemicals used at or generated by the sources associated with the known chemicals in the groundwater contained within the capture zones of the subject production wells.

2.3.1 Jet Propulsion Laboratory

Sources included an electronic database search, a records review for JPL (previous reports and investigations that include reviews of manifests and interviews with personnel), and a review of National Archives and Records Administration files related to JPL.

2.3.1.1 Environmental Database Review

An electronic environmental database search was completed to identify potential chemicals used at or generated by the JPL facility. The search was completed using reasonably ascertainable environmental databases, including standard state and federal sources in accordance with the American Society of Testing Materials (ASTM) Standard Practice E1527-00. In general, the use of ASTM E1527-00 is on a voluntary basis, for those wanting to assess the environmental condition of commercial property. As the standard states, it is primarily used as a guide to conducting an inquiry to identify recognized environmental conditions in connection with a property. Appendix C provides the environmental database review, which includes the list of federal and state databases searched.

The chemicals identified as used at JPL from the electronic database search are summarized in Table 2-6. The chemicals identified were either listed as a “NPL contaminant,” listed on a manifest, reported as a spill/leak, or identified as a substance in an underground storage tank (UST). The chemicals listed are metals, petroleum-related chemicals, and constituents of solvents, primarily VOCs.

2.3.1.2 Review of Previous Investigations and Studies for JPL

The following reports were reviewed to identify chemicals used at or generated by NASA:

- ❑ Ebasco Environmental (1988), PA/SI Report for Jet Propulsion Laboratory.
- ❑ Ebasco Environmental (1990a), Expanded Site Inspection Report for NASA-Jet Propulsion Laboratory.
- ❑ Ebasco Environmental (1990b), Supplemental Information to the Expanded Site Inspection Report on the NASA-Jet Propulsion Laboratory.
- ❑ JPL Groundwater Sampling Program (1993), Summary of Groundwater Sampling Events Completed at JPL Prior to the CERCLA RI/FS.

- ❑ Foster Wheeler Environmental Corporation (1999a), Final RI Investigation for Operable Units 1 and 3: On-Site and Off-Site Groundwater.
- ❑ Foster Wheeler Environmental Corporation (1999b), Final RI Investigation for Operable Unit 2: Potential On-Site Contaminant Source Areas.
- ❑ Foster Wheeler Environmental Corporation (2000), Draft FS for Operable Units 1 and 3: On-Site and Off-Site Groundwater.

Table 2-7 lists chemicals that were identified based on these previous studies and investigations.

2.3.1.3 National Archives and Records Administration Review

Historical records for NASA and JPL were reviewed to identify chemicals used at the JPL facility. The records were reviewed at the National Archives and Records Administration (NARA), Pacific Region, located in Laguna Niguel, CA. The following files were reviewed:

- ❑ Western Support Office, Central files for 1939-1962
- ❑ NASA Resident Office, Legal Opinion files for 1957-1974
- ❑ NASA Pasadena Office Cryogenics Branch, Contracts, Pressurants, Propellants files for 1965-1972
- ❑ JPL, Research and Development files for 1967-1984
- ❑ JPL, Publication Records Set files for 1967-1985
- ❑ JPL, Upper Level Management files for 1960-1967
- ❑ JPL, Contract Administration files for 1971.

Chemicals identified as part of this historical records review (i.e., National Archives and Records Administration Review) are listed in Table 2-8. These chemicals were used for various research activities at JPL and were identified from research and purchase records. The chemicals identified are primarily fuel propellants, coolants, and chemicals related to electronics research.

2.3.1.4 Summary of Chemicals Used at or Generated by JPL

Chemicals presented in Table 2-6 (Environmental Database Review), Table 2-7 (Previous Studies and Investigations), and Table 2-8 (National Archives and Records Administration Review) were combined into one summary table (Table 2-9). All identified chemicals that have been used at or generated by JPL are summarized on this table.

2.3.2 Upgradient Groundwater

Forty-one chemicals have been detected at least once in one or more of the four Valley Water Company Wells, which represent upgradient groundwater in the area of the production wells (Table 2-3). Of these 41 detected chemicals, 15 are VOCs, one is perchlorate, 17 are metals, and 8 are radioisotopes.

Perchlorate

The Regional Water Quality Control Board, Los Angeles Region (RWQCB) reports in a memorandum dated April 28, 2003, that perchlorate has been detected at more than 173 surface

water and groundwater sampling points within the Los Angeles Region at levels ranging from 4 to 159 µg/L (Dickerson, 2003). A RWQCB memorandum dated January 24, 2003, states, “33% of the source sites contributing to the perchlorate impact in groundwater are known, but many sources are unknown” (Dickerson, 2003).

It is also noteworthy that a major perchlorate release by Kerr McGee Corporation impacted the Las Vegas Wash, a tributary to Lake Mead and the lower Colorado River. The Colorado River is a major source of water for the Metropolitan Water District (MWD). As reported by Dickerson (2003), initial concentrations in the Las Vegas Wash area were as high as 3,700,000 µg/L, and concentrations in Lake Mead were as high as 10 µg/L. Perchlorate levels in lower Colorado River water now range from 4 to 9 µg/L. As stated in the RWQCB memorandum, “the potential impact of perchlorate contaminated imported water from the Colorado River, the probable lack of publicly owned treatment works (POTWs) removal capability, and the possibility that groundwater spreading/recharge projects may play a role in spreading perchlorate pollution are all concerns worth noting” (Dickerson, 2003).

PCE and Nitrates

The City of La Cañada-Flintridge is located in the San Gabriel Valley in the County of Los Angeles and is approximately 8.6 square miles in size (Willdan, 2003). This city is one of a few communities within the greater Los Angeles region that still relies on septic systems for sewage disposal. Of 6,989 homes in the area, only 2,218 units are served by a central sewage system, and many of the systems outside the central system are aged and failing (Willdan, 2003). The La Cañada-Flintridge Department of Public Works continues to receive numerous reports of septic overflows and failures annually. Septic overflows and system failures lead to sanitary and public health concerns, including the potential for contamination of drinking water supplies when sewage collects around water lines.

In addition to the sanitary and public health concerns of sewage overflow, the presence of PCE and elevated concentrations of nitrates in regional groundwater (e.g., Verdugo Basin, upgradient and along Foothill Boulevard) have been associated with historic uses of cesspools and septic systems (personal communication with DHS) in the La Cañada-Flintridge area. PCE was used as a septic system cleaner, whereas nitrates are byproducts of wastes contained within the septic systems. Excerpts taken from information posted by EPA Region 9 regarding the Verdugo Basin in the San Fernando Valley is provided below:

- The maximum concentration of PCE reported in the Verdugo Basin is 52 µg/L during July 1989. The area of greatest PCE groundwater contamination was located in and near the Glenwood well field, where historic concentrations averaged between 5 µg/L and 20 µg/L throughout the 1980s. The most recently available data (2002) indicate PCE concentrations of less than 1.4 µg/L in the Glorietta well field, and less than 2.3 µg/L in the Glenwood/Mills well field. Current PCE levels in the Verdugo Basin are below the federal and state MCL of 5 µg/L. Overall, PCE in the Verdugo Basin is less widespread and at lower concentrations than in the past.
- To date, the maximum concentration of nitrate detected in the Verdugo Basin is 101 mg/L during February 1995. Between 1988 and 2002, nitrate values in the Glorietta and Glenwood well fields have remained at approximately the same concentrations, with ranges from 25 to 50 mg/L and 40 to 90 mg/L, respectively. The maximum

concentration of nitrate in EPA's monitoring wells is 86.8 mg/L detected in 1993. Potential sources of nitrate contamination include fertilizer applied during agricultural practices, animal waste from confined animal facilities, and septic tank effluent.

2.4 Identification of Other Potential Sources and Determination of the Vulnerability of the Source Water to these Other Sources

This section describes the resources that were reviewed to identify other potential sources that could adversely impact groundwater quality within the capture zones of the production wells. Additionally, based on the identified potential sources, a list of chemicals used at or generated by the source was developed. Finally, a qualitative determination is presented describing the vulnerability of the groundwater within the capture zones of the production wells to the chemicals associated with the other potential sources. The vulnerability of the groundwater varies depending on the nature of the activity, types of chemicals used, potential for release to groundwater, and distance from the production wells.

2.4.1 Identification of Other Potential Sources

To identify potential sources based on activities and types of chemicals, a search from the Environmental Data Resources (EDR) Search Report (EDR, 2002) was completed. This report compiles information from various local, state, and federal resources including files, records, and databases. Many of the sites identified in the EDR report treat, store, or dispose of hazardous material. These sites are required to register the use of these compounds with federal, state, or local agencies. The information from these resources was gathered, compiled, reviewed, and evaluated to identify the potential sources.

The search was completed using reasonably ascertainable environmental databases, including standard state and federal sources in accordance with the ASTM Standard Practice E1527-00. The approximate minimum search distance is based on varying factors (as summarized in Section 7 of the ASTM Standard Practice E1527-00), but defined to be one mile for properties on the federal NPL site list. Therefore, an approximate 1-mile radius area was applied, centered at the JPL site. In addition, an approximate 1-mile search was conducted centered at the Arroyo Well. The combined search area is shown on Figure 2-33 and the identification numbers associated with this figure are presented in Table 2-10. Appendix C contains a brief description of each database searched, along with the ASTM list of records, including the resulting number of sites identified within the ASTM search distance.

The potential sources identified in the EDR search have been grouped by type of site and summarized below.

2.4.1.1 Landfills

Sanitary landfills, dumps, and other related waste disposal sites are potential sources of chemicals in groundwater. Three inactive landfills were identified in the Solid Waste Facility (SWF)/Landfill Facility (LF) database that are located within the study area:

1. NASA-JPL Dump, also known as the George Hagan Dump – 4800 Oak Grove Drive, Pasadena, CA. This former disposal site was located northwest of the Arroyo Well and Well 52, on the JPL property. According to California’s Solid Waste Information System, this was listed as a solid waste disposal site that is now closed. Information regarding the dump was not on file at the Solid Waste Management Program within the Los Angeles County DHS (personal communication between Battelle and the Los Angeles County DHS), indicating that a permit for the dump may have been filed with the county years ago, but use of the dump for permitted application did not occurred. Records regarding the use of this dump were not available.
2. Millard Cañon Dump – 3900 Cañon Crest Road, Altadena, CA. This former disposal site is located northeast of the Arroyo Well and Well 52. According to a Closed Site Assessment Form dated October 13, 1995, obtained from the Los Angeles County DHS, the Millard Cañon Dump was operated by the Los Angeles County Road Department during 1969 and 1972. The site was basically an unlined pit that was used to dispose of inert material (e.g., dirt and street repair material) left behind by a heavy rainfall. Some equipment (i.e., tractor, car parts) that had been left behind is now part of the dump. Only the north side of Millard Cañon was filled with the material. A copy of the Closed Site Assessment Form is included in Appendix D.
3. Lincoln Debris Disposal Area – 600 Loma Alta Drive. This former solid waste disposal site is located northeast of the Arroyo Well and Well 52, and was operated by the Los Angeles County Flood Control District. It is closed and not currently regulated.

2.4.1.2 Hazardous Waste Generators

A Resource Conservation and Recovery Information System (RCRIS) large quantity generator (LQG) and RCRIS small quantity generators (SQGs) were identified within the study area. The type of activity and type of wastes (if reported) associated with each waste generator is presented in Table 2-11. Information on the type of wastes generated by six of the 14 RCRIS sites was not available. Information about the location of the RCRIS sites with reported wastes is presented below:

1. JPL – 4800 Oak Grove, La Cañada, CA 91011. The site is located northwest of the production wells, on the JPL property.
2. Crystal Cleaners – 444 Foothill Boulevard, La Canada, CA 91011. The site is located west of the production wells.
3. Thomas A. Edison Elementary School – 3126 N. Glenrose Avenue, Altadena, CA 91001. This site is located west of the production wells.
4. Autosport Engines – 741 W. Woodbury Road, Altadena, CA 91001. This site is located south of the PWP and LAWC production wells, and west of the Rubio Cañon and Las Flores production wells.
5. 1X Mobil Oil/Mobil Oil Corp – 15 W. Woodbury Road, Altadena, CA 91001. This site is located south of the production wells.

6. Pasadena USD – 740 W. Woodbury Road, Altadena, CA 91001. This site is located south of the PWP and LAWC production wells, and west of the Rubio Cañon and Las Flores production wells.

2.4.1.3 Underground Storage Tanks

The State Water Resources Control Board (SWRCB) leaking underground storage tank (LUST) database contains an inventory of reported leaking underground storage tank incidents (i.e., reported releases). Nine LUST sites were reported within the study area. Table 2-12 summarizes the status of these LUST sites.

Additional information for these LUST sites is provided below:

1. ARCO #1684 – 550 Foothill Boulevard West, La Cañada-Flintridge, CA 91011. The property is located west of the production wells. Soil and groundwater were impacted by gasoline that was released from a leaking underground storage tank in 1991. A Preliminary Assessment was conducted in 1989. A Remediation Plan was developed and a Pollution Characterization was completed in 1992. Methyl-*tert*-butyl ether (MTBE) was detected in groundwater in 1995. The oversight agency (RWQCB) determined that remedial action was completed or deemed unnecessary, and the case was subsequently closed in 1996.
2. Flintridge Riding Club – 4625 Oak Grove Drive, La Cañada-Flintridge, CA 91011. The property is located southwest of the Arroyo Well and Well 52. Soil was contaminated with an unknown substance that was released from a leaking underground storage tank. The Local Implementing Agency (LIA) determined that remedial action was completed or deemed unnecessary, and the case was subsequently closed in 1990.
3. JPL – 4800 Oak Grove, La Cañada, CA 91011. The property is located northwest of the production wells, on the JPL property. Gasoline was released in the soil from a LUST located at the facility in 1990; the UST was subsequently closed in 1990.
4. Oak Grove Ranger Station – 4600 Oak Grove Drive, La Cañada-Flintridge, CA 91011. The property is located south and west of the production wells. Soil was contaminated with gasoline that was released from a leaking underground storage tank in 1990. The tank was closed, but the site was not tested for MTBE. The current site status is unknown.
5. Pacific Bell – 4815 Oak Grove Avenue, La Cañada, CA 91011. The property is located northwest of the production wells. Soil was contaminated with diesel fuel that was released from a leaking tank in 1990. It was determined that remedial action was completed or deemed unnecessary, and the case was subsequently closed in 1991.
6. Szkiba Auto (Former) – 3081 Lincoln Boulevard North, Altadena, CA 91001. The property is located east of the PWP production wells and north of the LAWC, Rubio Cañon, and Las Flores production wells. During tank closure in 1990, soil was discovered to be contaminated with gasoline that was released from a leaking underground storage tank. The tank was closed, but the site was not tested for MTBE. The RWQCB determined that Remedial Action was completed, and the case

was subsequently closed in 1996. According to the California's Hazardous Waste Information System (HAZNET), it appears that 1.3 tons of soil were removed from this location.

7. LA County Fire Station #12 – 2760 Lincoln Avenue, Altadena, CA 91001. The property is located east of the PWP and LAWC production wells, and north of the Rubio Cañon and Las Flores production wells. The report indicated that there was a release of gasoline to soil which was discovered in 2001. The status of the site was not reported.
8. Transamerica Financial Services – 620 W. Woodbury Road, Altadena, CA 91001. The property is located south of the PWP and LAWC production wells, and southwest of the Rubio Cañon and Las Flores production wells. A release of unknown product to soil occurred in 1996. The case is reported as closed, however the status of the investigation is unknown.
9. USDA Forest Service – Oak Grove Drive North, La Cañada, CA 91011. The property is located west of the PWP and LAWC production wells and northwest of the Rubio Cañon and Las Flores production wells. Soil was contaminated with gasoline that was released from a leaking underground storage tank in 1990. The tank was closed, but the site was not tested for MTBE. A remediation plan was developed in 1990. Pollution Characterization was conducted in 1991; current status of the site is unknown.

2.4.1.4 Documented Spills/Leaks/Discharges

Information retrieved regarding accidental releases or spills is presented as follows:

1. Los Angeles County Public Works – 4001 Canyon Dell Drive, Altadena, CA. A release of 200 gallons of untreated sewage was reported in November 1988. Information for this release was retrieved from the EPA's Emergency Response Notification System (ERNS), which reports releases of oil and hazardous substances.
2. 4800 N. Oak Grove Drive – Pasadena, CA 91109. A five-gallon release of liquid chromic acid occurred at this facility in February 1988. Information regarding environmental impact, cleanup, and status are not reported. The release was reported in the California Hazardous Material Incident Report System (CHMIRS), which reports on accidental releases or spills.
3. 292 N. Figueroa Drive (private residence) – Altadena, CA 91001. A one-gallon release of muriatic acid (hydrochloric acid) in the driveway of a private residence occurred in 1998. The fire station was called to clean it up. No information regarding additional environmental investigation is available.
4. 7073 Woodbury Road – Altadena, CA 91001. A five-gallon release of printing press cleaner-solvent (trade name ML2) occurred in 1990. No information regarding additional environmental investigation is available.

2.4.1.5 Treatment Plant Effluent Water

A review of historical records and files did not identify a treatment plant effluent site location within the study area. However, one waste discharge system (WDS) site was identified from the environmental database search due to active waste discharge permit:

1. Lincoln Avenue Water Company/South Coulter Water Treatment Plant – 564 West Harriet Street, Altadena, CA 91001. The facility designation of Category C refers to miscellaneous wastes, which include wastes from dewatering, recreational lake overflow, swimming pool wastewater, water park wastewater, groundwater seepage, and other similar wastes. Additionally, the designation is associated with influent or solid wastes that pose a threat to water quality because of high concentrations of biochemical oxygen demand (BOD), hardness, chloride, etc. The facility is located east of the PWP production wells and northwest of the Rubio Cañon and Las Flores production wells, and is not expected to pose a threat to groundwater.

2.4.2 Chemicals Potentially Impacting Groundwater

A summary of the specific chemicals and classes of compounds identified for the potential sources within the capture zones of the production wells is presented in Table 2-13. The list of chemicals from known sources (Table 2-9) was combined with the list of chemicals from potential sources (Table 2-13) to create Table 2-14 which is a summary of chemicals from known and potential sources. These data were used to determine the analyte list for the comprehensive groundwater monitoring event, as explained in Section 3.0.

2.4.3 Assessment of the Vulnerability of the Drinking Water Source

This section provides a general assessment of the vulnerability of the groundwater in the capture zones for the production wells, to the chemicals identified in Table 2-14. Figure 2-33 shows the locations of known and potential chemical sources within the study area and the vicinity of the production wells. The source locations are marked numerically or with a letter, which are described in Table 2-10.

The vulnerability of the groundwater to individual facilities within the search area is summarized in Table 2-15. Facilities that are located within the capture zone and upgradient of the groundwater flow path were reviewed to determine whether the groundwater within the capture zone would be vulnerable to chemical releases. Because these known and potential chemical sources are located within and/or upgradient of the study area, the potential vulnerability of the groundwater to these sources is greater than compared to the other potential chemical sources identified from the database search (i.e., those sources outside the capture zone and downgradient). The groundwater was determined to be vulnerable if the facility had a chemical release in the past and/or if the facility had been identified as being associated with the use or storage of chemicals listed in Table 2-14.

As shown on Table 2-15, the groundwater is potentially vulnerable to at least 14 facilities located directly within the capture zone. These 14 facilities are primarily comprised of automotive service/repair shops and dry cleaners. Petroleum hydrocarbons and chlorinated

solvents are common chemical constituents associated with these types of facilities. In addition, there are 10 facilities located within the capture zone that were registered in at least one of the environmental databases, but chemicals associated with these facilities were not listed.

For facilities located outside the capture zone, but upgradient of the study area, the groundwater is potentially vulnerable to at least nine facilities primarily comprised of automotive service/repair shops and dry cleaners. In addition, there are 14 facilities that were registered in at least one of the environmental databases, but chemicals associated with these facilities were not listed.

Based on the results of the environmental database search which identified the locations of potential source facilities within and upgradient of the study area, the groundwater may be considered most vulnerable to activities associated with automotive service/repair shops and dry cleaners in addition to activities associated with JPL.

2.5 Summary

This section provides a summary of the SWA, including detected chemicals, known and potential chemical sources, chemical concentration trend levels, chemicals potentially impacting groundwater, and the vulnerability of the groundwater located within the capture zones for the Monk Hill production wells.

2.5.1 Detected Chemicals

A summary of chemicals detected within the capture zones of the production wells is provided in Table 2-16.

2.5.2 Known and Potential Sources

VOCs and perchlorate are the primary known chemicals in groundwater located in the capture zones of the Monk Hill production wells. VOCs and perchlorate have been detected at the JPL CERCLA site and in upgradient groundwater.

Potential sources within the source water that may impact groundwater from the production wells were identified from an environmental database search for sites that are NPL-listed; that generate, store, treat, or transport hazardous waste; or have reported spills, LUSTs, or USTs (see Table 2-10).

2.5.3 Chemical Level Trends

Overall, no clear trend was observed for the VOCs and perchlorate concentrations in the JPL monitoring wells (Figures 2-24 to 2-32). Concentrations for the VOCs generally appear to be decreasing; however, some increases in TCE, PCE, or carbon tetrachloride have been observed in two monitoring wells (Screen 1 of MW-24 and Screen 3 of MW-3). Perchlorate concentrations generally have been increasing in the monitoring wells, but intermittent decreases were observed in three wells (Screen 2 of MW-4, Screen 3 of MW-3, and Screen 2 of MW-24).

It is difficult to predict the future VOC and perchlorate trends due to changing groundwater conditions. However, over the long term, the VOC and perchlorate concentrations are expected to decrease because of the remedial actions being implemented at JPL for soil and groundwater to reduce concentrations of these constituents. In addition, the efforts in La Cañada-Flintridge to obtain sanitary sewer connections at unsewered residences (potential sources of nitrate and PCE) will most likely result in future decreases of concentrations of these constituents.

2.5.4 Chemicals Potentially Impacting Groundwater

A summary of the chemicals that have not been detected in groundwater, but are associated with known and other potential sources, is presented in Table 2-17.

2.5.5 Vulnerability of Aquifer

The source water aquifer is vulnerable to chemicals, primarily VOCs and perchlorate, that have been associated with historic activities at the JPL facility. Also, the source water is vulnerable to the upgradient groundwater, which is known to contain VOCs, nitrate, and perchlorate.

Other facilities that have the greatest potential to impact groundwater within the capture zones of the production wells are automotive service/repair shops and dry cleaners. Petroleum hydrocarbons and chlorinated solvents are common chemical constituents associated with these types of facilities.

3.0 Raw Water Quality Characterization

The primary goal of the Raw Water Quality Characterization (RWQC) is to evaluate the water quality of groundwater extracted from the nine Monk Hill production wells. This includes estimating concentrations of known and potential chemicals and specific water quality parameters that may affect treatment plant design, and identifying chemicals of potential concern (COPCs) in groundwater using a screening comparison of chemical concentrations to applicable water quality standards.

Raw water quality is first evaluated by examining the historical data associated with each of the nine production wells. The data include samples collected and analyzed by the drinking water purveyors in accordance with the monitoring requirements of California Code of Regulations (CCR) Title 22. These historical data represent the best estimate of raw water quality for these production wells when extraction is resumed. The historical monitoring data for these wells are discussed in greater detail in Section 3.1. The historical raw water quality is further characterized by examining the variability of chemical concentrations with respect to time and seasonal effects as discussed in Section 3.2.

Raw water quality then is characterized by evaluating the water quality within the various capture zones described in the SWA (Figures 2-1 through 2-4). This evaluation serves as a way to estimate the water quality potentially associated with the influent to each of the water treatment plants proposed for the JPL remedial action. A water treatment plant is more likely to be installed to handle multiple production wells, as opposed to installing one plant per production well. Therefore, subsets of data have been formed by combining historical data from each of the production wells within the capture zone, supplemented with data from JPL monitoring wells located within the capture zone. These data are used to supplement the data collected from the production wells in order to evaluate chemicals that were not analyzed for in samples collected from production wells and to help predict future concentrations. Water quality characterization for estimated water treatment plant influent is discussed in greater detail in Section 3.3.

Water quality standards used for screening include California state regulatory criteria for drinking water: Primary MCL, secondary MCL, public health goals (PHGs); and action level (AL). The lowest concentration of the primary MCL, secondary MCL, or AL was used as the applicable regulatory limit for each analyte. The PHGs were not considered applicable regulatory criteria because they are derived using risk assessment methodology and do not consider other risk management aspects such as chemical detectability and treatment. In addition, PHGs are not enforceable and do not require notification to the public if exceeded. Although secondary MCLs and ALs are not enforceable, they are considered applicable regulatory criteria because an exceedance of a secondary MCL is required to be reported to DHS and an exceedance of an AL is required to be reported to the governing board of the local agency in which users of the drinking water reside. Additional details on the regulatory programs for these standards are provided in Appendix E.

3.1 Raw Water Quality Based on Historical Production Well Data

Tables 3-1 through 3-9 summarize the water quality monitoring data for each of the Monk Hill production wells. Included are the number of samples, number of detections, frequency of detection, minimum and maximum detected values, and the arithmetic mean. Also provided on these tables are water quality regulatory limits to compare to maximum and average concentrations determined for each of the chemicals. Maximum and average concentrations exceeding applicable regulatory criteria in groundwater are indicated with shading on the tables. The regulatory values are discussed in detail in Appendix E.

3.1.1 Arroyo Well and Well 52

Monitoring data for the Arroyo Well and Well 52 were obtained from the DHS Drinking Water Program and PWP. The review included data from groundwater samples collected during the late 1980s through June 2002. Sample results are available approximately yearly from the late 1980s through 1994, and then quarterly until 1997 for the Arroyo Well, and until 2002 for Well 52. Because the Arroyo Well ceased operating in 1997, there is limited data from 1998 to 1999, and the few samples available during this period may not be representative of pumping conditions. Use of Well 52 was stopped in early 2002. Although these wells were no longer used for production purposes, groundwater sampling and analysis continued to be performed up until early 2002.

Tables 3-1 and 3-2 summarize the historical monitoring data for the Arroyo Well and Well 52, respectively. For the Arroyo Well (Table 3-1), 36 chemicals have been detected at least once and 178 additional chemicals have not been detected, excluding general physical/chemical parameters (e.g., turbidity, alkalinity, total dissolve solids). For Well 52 (Table 3-2), 34 chemicals have been detected at least once and 185 additional chemicals have been analyzed for but not detected, excluding general physical/chemical parameters. Boron, hexavalent chromium, vanadium, and combined radium 226/228 were analyzed for in groundwater collected from Well 52, but were not analyzed for in groundwater collected from the Arroyo Well. Some of the chemicals detected are naturally occurring, including metals (aluminum, arsenic, barium, boron, calcium, chromium, iron, lead, magnesium, mercury, molybdenum, nickel, potassium, selenium, sodium, strontium, thallium, vanadium, and zinc) and radiological parameters (gross alpha, gross beta, radium 226, and radium 228).

A total of 43 chemicals have been detected at least once in either the Arroyo Well or Well 52. Twenty-five of the 43 chemicals were detected in both wells: barium, selenium, mercury, calcium, magnesium, sodium, potassium, sulfate, chloride, fluoride, nitrate, gross alpha particle activity, gross beta particle activity, zinc, radium 226, radium 228, uranium, perchlorate, carbon tetrachloride, chloroform, chlorthal, PCE, TCE, methylene chloride, and 1,2-DCA.

For both the Arroyo Well and Well 52 (Tables 3-1 and 3-2, respectively), screening against applicable standards resulted in maximum concentrations of six chemicals exceeding applicable drinking water standards: carbon tetrachloride, perchlorate, TCE, nitrate, bis(2-ethylhexyl)phthalate, and 1,2-DCA. Of these, only carbon tetrachloride and perchlorate had average concentrations that exceeded the applicable regulatory standard.

3.1.2 Ventura and Windsor Wells

For the Ventura Well and Windsor Well, analytical data were obtained from the DHS Drinking Water Program and the RBMB Database (Geoscience, 2004). Tables 3-3 and 3-4 summarize the monitoring data for the Ventura Well and Windsor Well, respectively. For the Ventura Well (Table 3-3), 35 chemicals have been detected at least once and 208 additional chemicals have not been detected, excluding general physical/chemical parameters (e.g., turbidity, alkalinity, total dissolved solids). For the Windsor Well (Table 3-4), 35 chemicals have been detected at least once and 138 additional chemicals have been analyzed for but not detected, excluding general physical/chemical parameters. Some of the chemicals detected in these production wells are naturally occurring, including metals (aluminum, barium, boron, calcium, chromium, iron, lead, magnesium, nickel, potassium, sodium, vanadium, and zinc) and radiological parameters (gross alpha, gross beta, radium 226, radium 228, and uranium).

A total of 43 chemicals have been detected at least once in either the Ventura Well or the Windsor Well. Twenty-five of the 43 chemicals were detected in both wells: barium, calcium, chloride, chloroform, chromium (total Cr-Cr[VI] Screen), chromium (total), chromium (hexavalent), combined radium 226/228, copper, fluoride, gross alpha, gross beta, iron, magnesium, nitrate, perchlorate, potassium, radium 226, radium 228, sodium, sulfate, PCE, total trihalomethanes, TCE, and uranium.

Based on the comparison to applicable standards, maximum concentrations of perchlorate, nitrate, and carbon tetrachloride were above standards in both the Ventura and Windsor Wells. None of the average concentrations exceeded applicable standards. The maximum concentration of iron was above the secondary MCL in the Ventura and Windsor Wells.

3.1.3 LAWC Well #3 and Well #5

For the LAWC wells, monitoring data from June 1991 to October 2002 and May 2003 through November 2003 for PCE, TCE, carbon tetrachloride, 1,1-DCA, and chloroform were used in the water quality characterization (Geoscience, 2004) (2003 data for all constituents were not available at this time. The dataset will be revised to include all data once 2003 data are obtained). Perchlorate data for these two wells were obtained from 1997 to June 2004. Table 3-5 summarizes the monitoring data for LAWC Well #3, and Table 3-6 summarizes the data for LAWC Well #5. For LAWC Well #3, (Table 3-5), 25 chemicals have been detected at least once and 222 additional chemicals have not been detected, excluding general physical/chemical parameters (e.g., turbidity, alkalinity, total dissolved solids). For LAWC Well #5 (Table 3-6), 22 chemicals have been detected at least once and 227 additional chemicals have been analyzed for but not detected, excluding general physical/chemical parameters. Some of the chemicals detected are naturally occurring, including metals (aluminum, calcium, chromium, iron, lead, magnesium, potassium, sodium, vanadium) and radiological parameters (gross alpha and uranium).

A total of 26 chemicals have been detected at least once in either LAWC Well #3 or LAWC Well #5. Nineteen of the 26 chemicals were detected in both wells: aluminum, bromodichloromethane, calcium, carbon tetrachloride, chloride, chloroform, fluoride, gross alpha, magnesium, nitrate, combined nitrate/nitrite, perchlorate, potassium, sodium, sulfate, PCE, TCE, uranium, and vanadium.

Maximum concentrations of TCE, perchlorate, and carbon tetrachloride exceeded applicable standards in both LAWC production wells. Average concentrations of TCE, carbon tetrachloride, and perchlorate also exceeded applicable standards in Well #3, but only average concentrations of TCE exceeded the applicable standard in Well #5. The maximum concentration of iron also exceeded the applicable standard in Well #3, but average concentrations were lower than the standard.

3.1.4 Rubio Cañon Well #4 and Well #7

Historical monitoring data for Rubio Cañon Wells #4 and #7 are summarized in Tables 3-7 and 3-8, respectively. Monitoring data was obtained from the DHS Drinking Water Program and the RBMB Database (Geoscience, 2004) and include samples collected from June 1985 through January 2003 for Well #4, and January 1987 through January 2003 for Well #7. Perchlorate data also are included for both wells through October 2003. Well #4 had 32 chemicals detected at least once and 204 additional chemicals that were analyzed but not detected, excluding general physical/chemical parameters (e.g., turbidity, alkalinity, total dissolved solids). Well #7 had 32 chemicals detected at least once and 107 additional chemicals that were analyzed but not detected, excluding general physical/chemical parameters (e.g., turbidity, alkalinity, total dissolved solids). As mentioned above, some of the chemicals detected in the Rubio Cañon production wells are naturally occurring, including metals (aluminum, barium, boron, calcium, chromium, iron, lead, magnesium, manganese, potassium, sodium, vanadium, and zinc) and radiological parameters (gross alpha, radium 226, radium 228, and uranium).

A total of 36 chemicals have been detected at least once in either the Well #4 or Well #7. Twenty-eight of the 36 chemicals were detected in both wells including: arsenic, aluminum, barium, boron, cadmium, calcium, chloride, chloroform, chromium (total), copper, fluoride, gross alpha, iron, magnesium, manganese, mercury, nitrate (as NO₃), nitrate + nitrite (as N), nitrate + nitrite (NO₃-N), perchlorate, potassium, selenium, silver, sodium, sulfate, uranium, vanadium, and zinc.

For Well #4 (Table 3-7), maximum concentrations of gross alpha and uranium exceeded applicable regulatory standards. The maximum concentration of perchlorate in Well #4 was equal to the AL of 6 µg/L. Average concentrations for these parameters, including perchlorate, were less than regulatory standards. For Well #7 (Table 3-8), maximum concentrations of fluoride exceeded applicable standards. The average concentration for this parameter was less than its regulatory standard.

3.1.5 Las Flores Well #2

Table 3-9 summarizes the monitoring data for Las Flores Well #2. The data set includes monitoring data for samples collected from June 1987 to September 2002, and additional data through June 2003 for chloroform, 1,1-dichloroethene (1,1-DCE), and carbon tetrachloride, through November 2003 for PCE, and through March 2004 for perchlorate (Geoscience, 2004). Well #2 has 29 chemicals that have been detected at least once and 212 additional chemicals that have not been detected, excluding general physical/chemical parameters (e.g., turbidity, alkalinity, total dissolved solids). Some of the chemicals detected are naturally occurring, including metals (aluminum, calcium, chromium, iron, lead, magnesium, potassium, sodium,

vanadium) and radiological parameters (gross alpha, gross beta, radium 226, radium 228, and uranium).

Maximum concentrations exceeding regulatory standards include those for gross alpha, nitrate, nitrate/nitrite, radium, uranium, hardness, specific conductance, PCE, and perchlorate. Only the average concentrations of perchlorate and PCE exceeded the applicable standard.

3.2 Variability of Perchlorate Concentrations Based on Historical Production Well Data

This section includes an evaluation of the variability of perchlorate concentrations in the groundwater from all of the production wells using the historical dataset for each production well. Identification of the variability of perchlorate concentrations is useful for the design of the treatment plant that will treat groundwater from each of the production wells. The variability analysis focuses on perchlorate because it is the primary chemical of interest identified in each of the wells.

This evaluation assumes that the prevailing hydrogeological conditions during collection of the data will not be altered significantly in the future. Moreover, the projection of variability of perchlorate does not consider potential future source removal or source control measures for this chemical.

Linear regression analyses have been performed using data from each of the production wells to project variability of chemical concentrations with time. Average monthly concentrations of chemicals were regressed with respect to time to project the trends in variability of chemical concentrations. Both short-term (seasonal) and long-term variabilities have been evaluated. A general decreasing trend in concentrations of these chemicals is observed in the data collected after January 18, 2002, apparently because Well 52 and other City of Pasadena production wells were not operating (City of Pasadena, 2003). Because the inclusion of these data would have skewed the regression analyses, data beyond January 18, 2002, were excluded.

3.2.1 Seasonal Variability

The variation of perchlorate concentrations in the production wells over time is shown on Figures 3-1 through 3-8. As evidenced in these figures, the seasonal variations in concentrations are not considered significant in any of the production wells.

3.2.2 Long-Term Variability

The long-term variability of perchlorate concentrations in the production wells over time is exhibited as trend lines shown on Figures 3-9 through 3-16. Evaluation of long-term variability of perchlorate concentrations is based on all available data from each of the production wells.

Perchlorate concentrations in groundwater from Well 52 ranged from approximately 10.5 to 38.8 µg/L during 1999 to 2002 (Figure 3-9). A trend analysis using the perchlorate data for Well 52 from June 1997 to January 2002 shows an increase in the perchlorate concentrations with

time. However, a decline in concentrations is noted after Well 52 was taken out of service on January 18, 2002 (City of Pasadena, 2003).

For the Arroyo Well, perchlorate concentrations show a slow, but steady increase from 1997 to 1999. Perchlorate concentration data from the Arroyo Well indicate an overall increasing trend (Figure 3-10).

For the Ventura Well (Figure 3-11), perchlorate concentrations have fluctuated over time, but overall show an increasing trend. Concentrations of perchlorate in the Windsor Well (Figure 3-12) have been more consistent over time than those in the Ventura Well, but show a similar increasing trend over time.

For LAWC wells, concentrations in LAWC Well #3 (Figure 3-13), the overall trend appears to be increasing. Perchlorate concentrations in LAWC Well #5 (Figure 3-14) have fluctuated over the years, but exhibit an overall increasing trend.

For Rubio Cañon Well #4 (Figure 3-15), perchlorate concentrations show a decreasing trend. Similarly, the perchlorate concentrations in Las Flores Well #2 generally have been decreasing over time (Figure 3-16).

In summary, it is difficult to accurately predict future analyte trends in the capture zones of the production wells due to changing groundwater conditions (i.e., the cessation of groundwater extraction from these production wells and other nearby extraction wells, and changes in the amount of recharged groundwater in the Arroyo Seco). However, the concentrations are expected to decrease in the future because of cleanup activities NASA is currently conducting for soil and on-facility groundwater, which are discussed in Section 4.0.

3.3 Estimates of Raw Water Quality for Water Treatment Plant Influent

For this evaluation, five separate influent streams are characterized:

- The Arroyo Well and Well 52
- The Ventura and Windsor Wells
- The Lincoln Avenue wells
- The Rubio Cañon wells
- The Las Flores well.

Chemical concentrations in the influent steam (i.e., the combined extracted water from the production wells) were estimated one of three ways: (1) using data obtained from select JPL wells sampled during the comprehensive groundwater monitoring event conducted at JPL; (2) using historical production well data supplemented with data obtained from the comprehensive groundwater monitoring event conducted at JPL; or (3) using only historical production well data. Assumed average time-weighted extraction rates (Table 2-1) for the production wells during system operation also were used where appropriate to estimate chemical concentrations in the influent.

The comprehensive groundwater monitoring event provides water quality data for additional analytes not previously analyzed in groundwater from these production wells required to be

analyzed by the DHS Policy Memorandum 97-005. Therefore, data obtained during the comprehensive groundwater monitoring event conducted at JPL from JPL monitoring wells located within the capture zones of the production wells are used in place of or to supplement the historical data from the Arroyo Well, Well 52, Ventura Well, Windsor Well, and the LAWC wells. For the Rubio Cañon and Las Flores wells, the results of the capture zone analysis indicate that none of the JPL monitoring wells sampled during the comprehensive groundwater monitoring event were located within these particular capture zones. Therefore, data obtained from the comprehensive groundwater monitoring event conducted at JPL were not used to supplement the data from these three production wells, historical data only were used to estimate influent concentrations.

A summary of all the analyses that were conducted on groundwater samples obtained during the comprehensive groundwater monitoring event is provided in Table 2-3. These analyses include all of the analytical requirements contained in Policy Memorandum 97-005, plus analytical parameters as requested by DHS for known and potential sources as identified in Section 2.0 of this report, and additional parameters necessary to evaluate requirements for the planned groundwater treatment. Details of the selection of analytical parameters for the comprehensive groundwater monitoring event are provided in Appendix F.

With DHS participation, certain JPL monitoring wells located within the capture zones were selected for sampling based on spatial distribution throughout the capture zones so that their analytical results could be used to estimate groundwater conditions in the Arroyo Well and Well 52. The JPL monitoring wells and multiport well screens selected for the comprehensive groundwater monitoring event and the rationale for their selection are provided in Table 3-10.

Estimation of water quality using water quality data for wells within each of the respective capture zones was intended to provide conservative results. The primary assumptions of the approach used to estimate water quality are: (1) chemicals detected in the JPL wells also will be present in the respective production well, and (2) concentrations of these chemicals in JPL wells will be representative of the concentrations in the production wells. The primary uncertainty associated with this approach is that the number of monitoring wells included in the capture zone provides only a rough estimate of the lateral and vertical variability in chemical concentrations and does not take into account the fact that some hydrogeologic units produce more groundwater than others. The method provides a conservative estimate of chemical presence and concentration.

The data used to estimate chemical presence and concentration for each of the influent streams are discussed in detail in Sections 3.3.1 through 3.3.5. The arithmetic mean is the primary statistic used in the discussions of the estimated water quality of the treatment plant influent. This value is considered to be appropriate because the production wells draw from the entire capture zone in which the monitoring wells are located and the groundwater is mixed in the well as it is discharged. Calculation of these statistical parameters incorporated one-half of the quantitation limits for all nondetect values and used averages of duplicate analyses. In addition, for comparison purposes, water quality regulatory limits also are provided on these tables to compare to maximum and average concentrations estimated for each of the chemicals. Chemicals having estimated influent concentrations exceeding regulatory criteria in groundwater are indicated on the tables. The regulatory limits are discussed in detail in Appendix E.

3.3.1 Arroyo Well and Well 52

The Arroyo Well was represented by the following JPL monitoring wells and ports: MW-3-3, MW-3-5, MW-4-1, MW-4-2, MW-8, MW-12-3, MW-12-5, and MW-18-4. Well 52 was represented by MW-4-2, MW-4-5, MW-10, MW-14-2, MW-14-4, MW-17-3, MW-17-4, and MW-18-3. Analytical results for each of the JPL monitoring wells used to represent the Arroyo Well and Well 52 were combined and evaluated. A summary of the analytical results for wells representing the Arroyo Well and Well 52 are provided in Table 3-11 and Table 3-12, respectively.

In most cases, the chemicals detected and the concentration estimates were similar to historical measurements in the production wells. The estimates for methylene chloride, however, are not considered to be acceptable due to anomalously high concentrations that may be the result of laboratory contamination of the samples collected during the comprehensive groundwater monitoring event. Laboratory contamination is suspected to have occurred because: (1) the quality control samples (e.g., trip blanks and field blanks) analyzed with the field samples indicated the presence of methylene chloride; (2) methylene chloride is a common laboratory contaminant; and (3) the data collected during the comprehensive groundwater monitoring event do not agree with historical monitoring data for JPL wells that indicate methylene chloride is present at low concentrations. Based on this supporting information, the estimated concentration of methylene chloride in the groundwater treatment plant influent will not be based on groundwater samples collected from the JPL wells, but rather will be based on the historical measured concentrations in the Arroyo Well and Well 52 (Tables 3-1 and 3-2, respectively). Therefore, the concentration of methylene chloride that most likely would be in the influent would be less than 0.5 µg/L, which is less than the primary MCL of 5.0 µg/L.

The estimate of perchlorate in Well 52 was the only significant difference observed between measured and estimated concentrations. The estimated average concentration (16.3 µg/L) for Well 52 is slightly lower than the average value (22 µg/L) based on previously measured concentrations. Although the estimated and measured concentrations do not exactly agree, both exceed the AL, indicating perchlorate is a concern for water quality. Appendix F provides detailed discussions regarding the historical data for the Arroyo Well and Well 52, results of the JPL comprehensive groundwater monitoring event, and estimations for the Arroyo Well and Well 52 by chemical analyses.

For the Arroyo Well (Table 3-11), maximum concentrations of turbidity, fluoride, iron, TCE, 1,2,3-TCP, perchlorate, carbon tetrachloride, and PCE exceeded applicable standards. Of these, average concentrations of TCE, 1,2,3-TCP, perchlorate, and carbon tetrachloride exceeded the applicable standard.

For Well 52 (Table 3-12), maximum concentrations of turbidity, manganese, color, TCE, and perchlorate exceeded regulatory standards. Of these, average concentrations of turbidity and perchlorate exceeded regulatory standards.

In order to estimate the chemical concentrations in the water treatment plant influent (i.e., the combined extracted water) from the Arroyo Well and Well 52, the data from the JPL wells representing these two wells were combined and evaluated. As shown on Table 2-1, the anticipated extraction rates for both these wells will be the same at 212 acre ft/month; thus equal contributions (i.e., equal flowrates) from both production wells were assumed during

derivation of the chemical concentrations in the influent. Table 3-13 presents the estimated water quality of the treatment plant influent. Estimated concentrations of perchlorate, 1,2,3-TCP, carbon tetrachloride, and turbidity exceeded applicable regulatory limits. The influent estimate for methylene chloride, however, is not considered to be acceptable due to anomalously high concentrations that may be the result of laboratory contamination of the samples collected during the comprehensive groundwater monitoring event.

Other findings summarized on Table 3-13 regarding the Arroyo Well and Well 52 estimated influent are described below.

Twenty-six naturally occurring constituents (e.g., metals and radionuclides); anions; general physical/chemical parameters; and 24 organic compounds (in particular, PCE and TCE) were detected in groundwater from the JPL monitoring wells sampled during the comprehensive groundwater monitoring event. However, average concentrations of these constituents did not exceed MCLs, or ALs or MCLs do not exist for these constituents. In addition, chemicals whose detection limits were higher than MCLs or ALs include aldrin, alpha-BHC, dieldrin, and benzo(a)pyrene. One analyte, 1,2-DCA, that had been historically detected in the Arroyo Well and Well 52, was not detected in JPL wells during the comprehensive groundwater monitoring event; however, 1,2-DCA is not considered to be a COPC in the influent, as explained in Section 3.5.1.

Chemicals were detected in groundwater from the monitoring wells located within the capture zones for the Arroyo Well and Well 52 that were not previously analyzed for in previous groundwater sampling events of the Arroyo Well and Well 52. The chemicals detected are 1,4-dioxane; propachlor; TNT; HMX; RDX; chlorate; TPH-D; and TPH-MO.

The estimated concentration of 1,4-dioxane (0.86 µg/L) for the groundwater treatment plant influent does not exceed the AL.

Propachlor was detected in only one groundwater monitoring well sample (MW-18-4) and is not expected to be present in the groundwater treatment plant influent.

NDMA was detected at a maximum concentration of 0.0058 µg/L in a monitoring well sample. This value does not exceed the AL of 0.01 µg/L. The estimated average concentration of NDMA in the groundwater treatment plant influent is 0.0013 µg/L, which does not exceed the AL. In addition, two other nitrosamines were detected: n-nitrosodi-n-propylamine, and n-nitrosodiphenylamine. Neither of these chemicals has regulatory standards. The average groundwater treatment plant influent concentrations are 0.0107 µg/L for n-nitrosodi-n-propylamine and 0.0036 µg/L for n-nitrosodiphenylamine.

Three explosive chemicals were detected in groundwater monitoring well samples during the comprehensive groundwater monitoring event that do not have MCLs or ALs. These chemicals are TNT, HMX, and RDX. The estimated average concentration of these chemicals for the groundwater treatment plant influent is 2.673 µg/L for TNT, 0.747 µg/L for HMX, and 2.868 µg/L for RDX. The maximum concentrations for these chemicals detected during the comprehensive groundwater monitoring event are 25.7 µg/L for TNT, 2.5 µg/L for HMX, and 27.3 µg/L for RDX. These compounds do not have regulatory standards.

Chlorate was detected in JPL wells, ranging from 0.073 to 0.875 mg/L. The estimated arithmetic mean concentration in the groundwater treatment plant influent is 0.225 mg/L. Chlorate does not have a regulatory standard.

Chromium (VI) was detected in JPL groundwater samples at concentrations ranging from 0.00049 to 0.0027 mg/L. The estimated arithmetic mean groundwater treatment plant influent concentration is 0.0005 mg/L. There is no specific regulatory standard for chromium (VI); however, concentrations detected, as well as the average estimated influent concentration, are much less than the primary MCL of 0.05 mg/L for total chromium.

TPH-D and TPH-MO were detected in JPL groundwater monitoring well samples at estimated concentrations below the practical quantitation limit (PQL). This limit for TPH-D and TPH-MO ranged from 0.96 to 1 mg/L. The estimated arithmetic mean concentrations for the groundwater treatment plant influent are 0.365 mg/L TPH-D, and 0.329 mg/L TPH-MO. The relatively high estimated concentrations of TPH-D and TPH-MO are the result of high detection limits (0.96 mg/L for both constituents). No regulatory standards exist for TPH.

3.3.2 Ventura and Windsor Wells

Chemical concentrations in the treatment plant influent for Ventura and Windsor Wells were estimated by combining the historical data from both wells and supplementing with data obtained from the comprehensive groundwater monitoring event for JPL wells, MW-19-3 and MW-21-3. As shown on Table 2-1, the anticipated extraction rates for both these wells will be the same at 98 acre ft/mo; thus equal contributions (i.e., equal flowrates) from both production wells were assumed during derivation of the chemical concentrations in the influent. Any chemical that was not present in the production well data, but detected in groundwater from JPL monitoring wells, MW-19-3 or MW-21-3, was included as being present in the influent. Influent concentrations of these constituents were derived as described above by assuming average concentrations of the two JPL monitoring wells existed in each of the production wells. Table 3-14 provides the estimated water quality of the treatment plant influent for these wells. None of the concentrations estimated exceed applicable regulatory limits.

3.3.3 LAWC Well #3 and Well #5

Chemical concentrations in the treatment plant influent for the Lincoln Avenue wells were estimated by combining the data from LAWC #3 and LAWC #5. Influent concentrations were determined by multiplying the average concentrations of each constituent detected in each well by the average flowrate of that well, summing these numbers together and dividing by the total flowrate. As shown on Table 2-1, an average flow rate of 40 acre ft/month was used for LAWC #3 and 44 acre ft/month was used for LAWC #5. Any chemical that was not present in the production well data, but detected in groundwater from JPL monitoring wells, MW-17-3 or MW-17-4, was included as being present in the influent. Influent concentrations of these constituents were derived as described above by assuming average concentrations of the two JPL monitoring wells existed in each of the production wells. The influent estimate for perchlorate was derived using only 2003 and 2004 data because perchlorate concentrations exhibited a sharp increase in these more recent sampling events; therefore, in order to capture a more conservative influent estimate, the 2003 and 2004 data were the only values used in

determining the influent estimate. Table 3-15 provides the estimated water quality of the treatment plant influent for these wells.

Estimated influent concentrations of perchlorate, carbon tetrachloride, and TCE exceeded applicable regulatory limits.

3.3.4 Rubio Cañon Well #4 and Well #7

Expected chemical influent concentrations for the Rubio Cañon Land and Water Association treatment plant were estimated by combining the data from Rubio Cañon Wells #4 and #7. As for the wells mentioned above, the expected influent concentrations were calculated by taking the sum of the average concentration of each detected constituent multiplied by the average flowrate for that well and then dividing by the total flowrate of both wells. As shown on Table 2-1, an average flow rate of 39 acre ft/month was used for Rubio Cañon Well #4 and 78 acre ft/month was used for Rubio Cañon Well #7. Table 3-16 provides the estimated water quality of the treatment plant influent for the Rubio Cañon wells. None of the concentrations estimated exceeded applicable regulatory limits.

3.3.5 Las Flores Well #2

The Las Flores Water Company has one production well. Therefore, the expected influent concentration for detected constituents was calculated using the average detected concentration for Las Flores Well 2. Table 3-17 summarizes the expected influent concentrations for the Las Flores Water Company. Concentrations estimated for nitrate, perchlorate, and PCE exceeded applicable regulatory limits.

3.4 Fate and Transport Modeling

In the previous section, raw water quality for the production wells was conservatively estimated using monitoring data from JPL wells, assuming concentrations in the production wells would be the same as concentrations in JPL wells. Given the conservative nature of this assumption, simple fate and transport groundwater modeling was conducted in order to predict if chemicals in JPL monitoring wells will reach the production wells at concentrations above screening criteria. The results of the model were used to predict future conditions from what is currently known about the groundwater quality on the JPL facility. Screening criteria used in the simulations were either California regulatory standards, or EPA Region 9 preliminary remediation goals for chemicals not having regulatory standards.

The Analytical Transient 1-, 2-, 3-Dimensional Model (AT123D) was used to perform the groundwater transport simulations. AT123D is an analytical model that computes the spatial distribution of chemical concentrations and predicts the migration of a plume through the aquifer. AT123D assumes the aquifer is homogeneous and isotropic and accounts for advection, diffusion, sorption, and decay. The groundwater model was set up to back-calculate the concentration that would need to be present a particular distance away from the production well which would result in concentrations exceeding screening criteria in the production wells.

Aquifer parameters from the JPL groundwater flow model (NASA, 2004) were used as input into the AT123D model. The parameters and values used are:

- Bulk density of 1,650 kg/m³
- Effective porosity of 0.3 (unitless)
- Hydraulic conductivity of 0.28 m/hr
- Hydraulic gradient of 0.008 ft/ft.

Several different sets of simulations were performed, incorporating different travel distances and assuming various transport mechanisms. Simulations were run for travel distances of 500 ft, 1,000 ft, 1,500 ft, 2,000 ft, 2,500 ft, and 3,000 ft and assumed an instantaneous (slug) source (i.e., a one-time release). These distances incorporate the majority of monitoring wells located upgradient of the Arroyo well in which chemicals have been detected and monitored. Figure 3-17 provides the radii of interest for the Arroyo Well, because this well is located nearest the JPL facility. Note that the groundwater model simulations are applicable to any of the production wells.

The first set of simulations assumed advection and dispersion as the transport mechanisms; no sorption was included in the simulations. Longitudinal dispersivity was estimated at one percent of the flow field (i.e., travel distance) and the transverse and vertical dispersivities were assumed to be 10% and 1% respectively, of the longitudinal dispersivity. These dispersivity values are commonly used rule of thumb estimates.

The second set of simulations included sorption along with dispersion and diffusion. Sorption was included via a chemical-specific distribution coefficient that is used in conjunction with other aquifer parameters to estimate a retardation factor that is applied to the advection/dispersion flowrate. Although chemical-specific distribution coefficients for some of the chemicals included in this study are available, the majority of coefficients are not. In addition, distribution coefficients are site-specific and none of the published values are representative of conditions on JPL. As a result, order of magnitude estimates of the distribution coefficients (0.001, 0.01, 0.1, and 1.0 mL/g) were used that span the range of acceptable and probable values.

Table 3-18 presents the results of the modeling simulations for each of the selected chemicals. Chemicals selected to be modeled were those that have been detected in both the JPL wells and the production wells (e.g., perchlorate, TCE, PCE, carbon tetrachloride) and others that were identified in Section 2.2.3 that are relatively new detections in JPL wells (2,4,6-TNT, HMX, RDX, NDMA, n-nitrosodipropylamine, n-nitrosodiphenylamine, chlorate, propachlor, 1,2,3-TCP, and 1,4-dioxane).

The concentrations summarized on Table 3-18 are the estimated concentrations that have to exist a particular distance away from the production well so that migration of the constituent in groundwater would not exceed the target level (i.e., a drinking water standard, action level, or EPA Region 9 PRG) once it reached the production well.

For illustrative purposes, the Arroyo Well is used to demonstrate the results of the groundwater simulations by comparing the range of concentrations detected in JPL wells (those wells located within the various radii shown on Figure 3-17) to concentrations estimated from the groundwater simulations (assuming no sorption). Concentrations detected in JPL wells are compared to the estimated concentrations required to meet the target level as summarized in

Table 3-19. Based on comparison to the results of the model, four of these constituents (perchlorate, carbon tetrachloride, TNT, and RDX) have been detected in JPL wells at least once since 1996 at concentrations that would result in concentrations exceeding target levels in the Arroyo Well. PCE has been detected in the Arroyo Well, but the detected concentrations did not exceed the MCL, which coincides with the modeling results. The modeling results also indicate that TCE concentrations in JPL wells were not detected at levels capable of causing exceedances of the MCL in the Arroyo Well; however, TCE has been detected in the Arroyo Well at concentrations exceeding the MCL.

The analytes 2,4,6-TNT, HMX, RDX, NDMA, n-nitrosodipropylamine, n-nitrosodiphenylamine, chlorate, propachlor, TCP, and 1,4-dioxane were never detected in the Arroyo Well (either because they were not analyzed for or detection limits were too high), but have been detected in JPL monitoring wells since the Arroyo Well was shut down. Based on the results of the model, none of these constituents, except for TNT and RDX, are at sufficient concentrations in JPL monitoring wells to result in levels exceeding drinking water target levels (i.e., MCLs, ALs, PRGs) (Table 3-19) in the Arroyo Well at some point in the future. Although there are no promulgated drinking water standards for TNT or RDX, the modeling results indicate that these two constituents are present in JPL wells at concentrations that may result in exceeding the EPA Region 9 PRGs at the Arroyo Well. Similar to the July 15, 2004 Permit Amendment for LAWC, when the PWP production wells are returned to service, samples will be collected for explosive compound analysis, including TNT, HMX and RDX.

3.5 Identification of Chemicals of Potential Concern

The purpose of this section is to identify COPCs and to estimate average and maximum concentrations that would be expected in the influent to the water treatment plant. This information is then used to provide input for treatment plant design.

COPCs are defined as chemicals that have exceeded applicable regulatory standards and are expected to be present in the influent. The purpose of identifying COPCs was to aid in the design of the water treatment system. The lowest concentration of the primary MCL, secondary MCL, or AL was used as the applicable regulatory standard for each analyte. Comparison to regulatory limits and exceedances were provided in Section 3.2 for average and maximum concentrations based on historical analytical data, and comparisons also were provided in Section 3.3 for concentrations estimated to be in the influent for each of the water treatment plants. The COPCs identified for each well and those subsequently identified in the influent to a particular water treatment plant are summarized in Table 3-20 along with the range of concentrations observed and are discussed below.

3.5.1 COPCs in the Arroyo Well and Well 52

Four chemical constituents have been identified as a COPC in the influent for the Arroyo and Well 52 (Table 3-20).

A comparison of perchlorate data shows that the measured average concentration and the estimated average influent concentration both exceed the AL of 6 µg/L. Therefore, based on historical and estimated concentrations, perchlorate is expected to remain a COPC for water treatment plant design.

Similarly, the measured and estimated concentrations for carbon tetrachloride exceed the primary MCL of 0.5 µg/L. The comparison of the carbon tetrachloride concentrations shows a close correlation with the historical data and the estimated data, which indicates that the MCL of 0.5 µg/L will be exceeded. Carbon tetrachloride is expected to remain a COPC for water treatment plant design.

For TCE, historical measurements exceeded the applicable regulatory standard; however the influent estimate was less than the standard. Looking more closely at TCE concentrations detected in more recent sampling events in JPL wells located in the capture zone (Tables 3-11 and 3-12), indicates that concentrations of TCE continue to be present above the primary MCL. Therefore, TCE will be a COPC for the water treatment plant design.

Historical data do not indicate 1,2,3-TCP was detected in the production wells, and 1,2,3-TCP was only detected once in JPL wells from 1985 to 2002. However, the analytical method used during this timeframe was only able to detect concentrations above 0.500 µg/L. During the comprehensive monitoring event, samples were analyzed for 1,2,3-TCP using a more sensitive analytical method that could detect concentrations as low as 0.005 µg/L. During this event, 1,2,3-TCP was detected in samples collected from JPL monitoring wells located within the capture zone of Arroyo Well and Well 52 (see Table 3-11). Therefore, 1,2,3-TCP is expected to be a COPC for water treatment plant design.

Although the estimated influent concentration for turbidity exceeds the applicable standard (Table 3-13), the measurement is most likely the result of monitoring well construction of the JPL wells, rather than water quality. Based on historical turbidity measurements obtained specifically for the Arroyo and Well 52, concentrations of turbidity ranged from 0.05 to 0.5 NTU, over the years these wells were in operation. These turbidity concentrations are much less than the applicable standard of 5 NTU and much less than those concentrations measured in the JPL monitoring wells. Differences in the construction of and development of production wells versus monitoring wells are likely contributing to the differences observed for turbidity measurements. Therefore, turbidity is not a COPC for the treatment plant design.

Three other constituents, 1,2-DCA, nitrate, and bis(2-ethylhexyl)phthalate, were detected in samples collected from production wells at maximum concentrations that exceeded the applicable standards (Tables 3-1 and 3-2). However, these compounds are not considered COPCs, based on the following:

- 1,2-DCA: This compound was detected only once in Well 52 in 1992 at 1 µg/L, but not detected above 0.5 µg/L thereafter (through January 2002). In the Arroyo Well, this compound was detected in the late 1980s and early 1990s, but not detected above 0.5 µg/L thereafter (through February 1998). In addition, this compound was not detected in JPL wells located in the capture zone for the Arroyo (Table 3-11) and Well 52 (Table 3-12).
- Bis(2-ethylhexyl)phthalate: This compound was detected only once in the Arroyo Well and Well 52 in 1985 at 5 µg/L. Samples collected from each well in 1993 indicated that this compound was below the detection limit of 3 µg/L. In addition, this compound was not recently detected in JPL wells located in the capture zone for the Arroyo (Table 3-11) and Well 52 (Table 3-12).

- Nitrate: For Well 52, nitrate was only detected once above the MCL at 55 mg/L in July 2001. Based on sampling results thereafter through June 2002, nitrate concentrations remained below the MCL of 45 mg/L. Similarly, the Arroyo Well had one exceedance of the MCL in April 1999 at 59 mg/L. Sampling data for nitrate after April 1999 do not exist, however, concentrations of nitrates in the JPL wells (Tables 3-11 and 3-12) were detected at concentrations much less than the applicable standard of 45 mg/L.

3.5.2 COPCs in Ventura and Windsor Wells

Perchlorate is identified as a COPC for the water treatment plant (Table 3-20), even though the estimated groundwater treatment plant influent for the Ventura and Windsor Wells is not expected to contain analytes with average concentrations that exceed MCLs or ALs (Table 3-14). Carbon tetrachloride has not been detected in either of the production wells since 2000. JPL monitoring wells MW-19 and MW-21 were nondetect for carbon tetrachloride in the comprehensive monitoring event. Based on these observances, carbon tetrachloride is not a concern for water treatment. Even though perchlorate concentrations were below applicable standards in the JPL wells located in the capture zone, concentrations continued to fluctuate and at times were above applicable standards in 2002 (data obtained prior to these wells being closed). And as evidenced on Figures 3-11 and 3-12, concentrations of perchlorate have been increasing over time (refer to Figures 3-11 and 3-12).

3.5.3 COPCs in LAWC Well #3 and Well #5

Three chemicals were above applicable standards. Both historical measurements and the estimated groundwater treatment plant influent indicated exceedances for these analytes (Table 3-20). For perchlorate, the estimated influent average concentration is 11.8 µg/L, above the AL of 6.0 µg/L. The estimated influent concentration for carbon tetrachloride is 0.6 µg/L, which exceeds the primary MCL of 0.5 µg/L. The estimated influent concentration for TCE is 10.7 µg/L, which exceeds the MCL of 5.0 µg/L. All chemicals and pH will be considered in the treatment plant design. Review of the pH concentrations from all of the other wells (production and JPL monitoring wells) indicates that pH for groundwater in the Monk Hill Subarea is approximately 7 and fairly neutral; thus pH is not a concern for water treatment.

3.5.4 COPCs in Rubio Cañon Well #4 and Well #7

The estimated groundwater treatment plant influent for Rubio Cañon Wells #4 and #7 is not expected to contain analytes with average concentrations that exceed MCLs or ALs (Table 3-20). Historical average concentrations did not exceed applicable standards, except for pH. Gross alpha, uranium, and perchlorate historical maximum concentrations were detected in 1997. All other sampling events subsequent to this resulted in maximum concentrations less than applicable standards. Similarly for fluoride, the maximum concentration was detected in 1992, with subsequent sampling results less than the applicable criteria. Review of the pH concentrations from all of the other wells (production and JPL monitoring wells) indicates that pH for groundwater in the Monk Hill Subarea is approximately 7 and fairly neutral; thus pH is

not a concern for water treatment. Therefore, none of these constituents are expected to be COPCs for treatment design.

3.5.5 COPCs in the Las Flores Well #2

The groundwater treatment plant influent originating from Las Flores Well #2 is estimated to contain three chemicals with average concentrations that exceed MCLs or ALs (Table 3-20). For perchlorate, the estimated influent average concentration is 6.24 µg/L, just slightly above the AL of 6.0 µg/L. The estimated influent concentration for PCE is 10.36 µg/L, which exceeds the Primary MCL of 5.0 µg/L. The estimated influent concentration for nitrate (as NO₃) is 45.95 mg/L, which very slightly exceeds the primary MCL of 45 mg/L. Similarly, nitrate/nitrite exceeds applicable standards, but will be addressed via the nitrate issue. Therefore, perchlorate, nitrate, and PCE will be addressed as COPCs in the water treatment design.

Maximum concentrations of gross alpha, hardness, and uranium were detected in 1988, 1999, and 1998, respectively. Maximum concentrations for these constituents were less than applicable standards in subsequent years. Therefore, these three analytes will not be a concern for water treatment design.

3.6 Summary

The Arroyo Well, Well 52, Ventura Well, and Windsor Well currently are closed and representative groundwater samples can not be collected until these wells are refurbished and in operating condition. For purposes of this report, the quality of the water extracted from these production wells when the treatment system begins was estimated using historical data from the wells and current data from select JPL wells located within the capture zone of each production well were used in place of actual sampling. Because the Lincoln Avenue, Rubio Canyon, and Las Flores wells continue to operate as production wells, current groundwater data for these wells were used to estimate groundwater quality. The groundwater data were evaluated for the presence of known and potential chemicals, concentrations of these chemicals, and specific water quality parameters that may potentially affect treatment plant design and/or end-use options for the treated water. Concentrations of analytes present in the influent to the four treatment plants were estimated and compared to applicable drinking water standards. Chemicals estimated to be present at concentrations exceeding applicable regulatory standards in the influent were identified as COPCs and carried forth for further evaluation in Section 5.0.

In addition to the approach used to estimate the contaminant concentrations in the PWP production wells, a simple fate and transport groundwater model was developed to predict if chemicals in JPL monitoring wells will reach the production wells at concentrations above screening criteria. Results of the fate and transport modeling indicate that four of the modeled constituents (perchlorate, carbon tetrachloride, TNT, and RDX) have been detected in JPL wells at least once since 1996 at concentrations that would result in concentrations exceeding target levels in the Arroyo Well.

4.0 Source Protection

DHS requires that the source(s) of chemicals in groundwater must be controlled to prevent chemical levels from increasing and to minimize the dependence on treatment. For groundwater extracted from the Monk Hill Subarea, source protection will be achieved by:

- ❑ Best management practices for waste handling and waste reduction at the JPL facility.
- ❑ Remedial action within the JPL facility (i.e., on-facility groundwater [OU-1] and on-facility soil [OU-2] at JPL).
- ❑ Additional protection activities at other sources within the Subarea.
- ❑ A communication plan involving NASA, the City of Pasadena, EPA Region 9, RWQCB, California Department of Toxic Substances Control (DTSC), DHS, and other interested parties including PWP, LAWC, Rubio Cañon, and Las Flores.

These source protection measures are discussed in detail in the following sections.

4.1 Best Management Practices for Waste Handling and Management

Management programs for waste handling and reduction are required under local, state, and federal regulations. Specifically, any facility within the source water area meeting the requirements of these regulations must comply with them. Compliance with these regulations is intended to be protective of the environment. A summary of these existing regulatory programs is provided below.

4.1.1 Hazardous Waste Generator Management Requirements (22 CCR §66262)

Standards for generators who treat, store, or dispose of hazardous waste on-site must comply with regulations for determining whether the generator has a hazardous waste, for obtaining an identification number, for accumulation of hazardous waste, and for recordkeeping.

4.1.2 Hazardous Waste Facility Permit – RCRA Treatment, Storage, and Disposal (22 CCR §66264)

This regulation establishes minimum standards that define the acceptable management of hazardous waste for owners and operators of facilities which transfer, treat, store, or dispose of hazardous waste.

4.1.3 California Hazardous Waste Treatment – Permit By Rule/Tiered Permit (22 CCR §67450 et seq.)

Permits are required for treatment of hazardous wastes using a Transportable Treatment Unit (TTU) or a Fixed Treatment Unit (FTU). These regulations identify proper operating and maintenance, record keeping, training, inspection, and spill response procedures for hazardous waste treated and managed on-site.

4.1.4 Hazardous Waste Source Reduction and Management Review Act of 1989 (SB-14 – H&SC §25244.12 et seq.)

This act applies to any generator routinely generating more than 12,000 kg of hazardous waste in a calendar year, or more than 12 kg of extremely hazardous waste in a calendar year; it also requires hazardous waste generators consider source reduction as the preferred method of managing hazardous waste. Source reduction is preferred over recycling and treatment because it avoids the generation of hazardous wastes and its associated management liability. A generator must prepare a Source Reduction Evaluation Review and Plan, Hazardous Waste Management Performance Report, and Summary Progress Report, and submit them to the Department of Toxic Substances Control.

4.1.5 Underground Storage Tank (23 CCR Division 3, Chapter 16)

The regulations in this chapter are intended to protect waters of the state from discharges of hazardous substances from USTs. These regulations establish construction requirements for new USTs; establish separate monitoring requirements for new and existing USTs; establish uniform requirements for reporting of unauthorized releases, and for repair, upgrade, and closure of USTs; and specify variance request procedures.

4.1.6 Aboveground Petroleum Storage Tank Act (H&SC §25270 et seq.)

This act is applicable for tanks of 10,000 gallons or more. The owner or operator of a tank facility must conduct daily visual inspections of any tank storing petroleum, allow the regional board to conduct periodic inspections of the tank facility, and install a secondary means of containment for the entire contents of the largest tank at the tank facility, plus sufficient space for precipitation if the regional board determines this installation is necessary for the protection of the waters of the state.

4.1.7 Oil Pollution Prevention (40 CFR §112)

This part establishes procedures, methods, and equipment and other requirements for equipment to prevent the discharge of oil from non-transportation-related onshore and offshore facilities into or upon the navigable waters of the United States or adjoining shorelines. This part provides for the preparation and implementation of Spill Prevention Control and Countermeasure Plans prepared in accordance with Sec. 112.7, and is designed to complement existing laws, regulations, rules, standards, policies, and procedures pertaining to safety standards, fire

prevention and pollution prevention rules, so as to form a comprehensive balanced federal/state spill prevention program to minimize the potential for oil discharges.

4.1.8 Oil Pollution Act of 1990 and California Oil Spill Prevention and Response Act (40 CFR §112.20 and OSPR §8670 et seq.)

These acts were adopted in response to rising public concern following the Exxon Valdez incident and to improve the nation's ability to prevent and respond to oil spills. In addition, these acts provide new requirements for contingency planning both by government and industry. Finally, these acts increased penalties for regulatory noncompliance, broadened the response and enforcement authorities of the federal government, and preserved state authority to establish law governing oil spill prevention and response.

4.1.9 California Business Plans and Superfund Amendments and Reauthorization Act (SARA) Title III (H&SC §25503.5 et seq. and 40 CFR §355 and §370)

These regulations are for the establishment of the list of extremely hazardous substances, threshold planning quantities, and facility notification responsibilities necessary for the development and implementation of state and local emergency response plans. These regulations establish reporting requirements that provide the public with important information on the hazardous chemicals in their communities for the purpose of enhancing community awareness of chemical hazards and facilitating development of state and local emergency response plans.

4.1.10 Acutely Hazardous Materials (H&SC §25531 et seq.)

Facilities using acutely hazardous materials over a certain quantity are required to prepare a risk management plan that provides for record keeping, proper design, handling, storage and training requirements. Also, these plans include potential release scenarios and action alternatives to deal with risk scenarios to prevent adverse effects to humans and the environment.

4.1.11 Uniform Fire Code (UFC)

The uniform fire code regulates the storage of hazardous materials within structures and outdoors. This code provides for specific design, construction, and operational requirements for containers, tanks, storage cabinets, and secondary containment areas.

4.1.12 Clean Water Act and Porter/Cologne Act: Surface Water Discharge

These acts authorize the SWRCB and RWQCB to establish water quality control plans, beneficial uses, and numerical and narrative standards to protect both surface water and groundwater

quality. They also authorize regional water boards to issue permits for discharges to land or surface or groundwater that could affect water quality, including NPDES permits, and to take enforcement action to protect water quality.

4.1.13 Clean Water Act – Porter/Cologne Act: Stormwater Discharge – General Permit

Prior to closure, inactive waste management units must comply with the substantive requirements for eliminating most non-stormwater discharges, developing and implementing a stormwater pollution prevention plan, and performing monitoring of stormwater discharges.

4.1.14 Clean Water Act: Wastewater Discharge to Publicly Owned Treatment Works

Wastewater discharged from industrial facilities to local publicly owned treatment works usually are required to obtain a wastewater discharge permit and to prepare pollution prevention plans to identify proper handling, storage, record keeping, and other procedures that prevent discharge of hazardous material to the sewer.

4.2 Remedial Actions for OU-1 and OU-2

In October 1992, JPL was placed on the NPL. As a NPL site, JPL is subject to the provisions of CERCLA as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, hereafter jointly referred to as CERCLA. In accordance with CERCLA requirements, remedial investigations were completed at the JPL site to characterize the nature and extent of chemicals in on-facility groundwater (OU-1) and soil (OU-2) identified in studies prior to and during the RIs.

NASA's cleanup plan for JPL includes concurrently addressing remediation of soil and groundwater. Summaries of the planned remedies are described below.

4.2.1 OU-1

An expanded treatability study is underway to support development of a full-scale remedial action to address chemicals of interest (i.e., VOCs and perchlorate) in on-facility groundwater (OU-1). The groundwater beneath the JPL facility contains elevated levels of chemicals that may represent a continuing source. The goal of the expanded treatability study is to test, at full scale, the most cost-effective treatment technology of the many technologies that were previously pilot tested on the JPL facility. The study will target an 8-acre by 100-ft-thick portion of the site (i.e., the test area), located in the north-central section of the JPL facility (see Figure 4-1).

An initial feasibility evaluation was conducted to determine potential remedial techniques for OU-1. The evaluation indicated that the preferred remedial technique includes targeted mass removal using groundwater extraction near the suspected chemical release with groundwater reinjection. Also, treatment technologies were evaluated to achieve groundwater reinjection

requirements. LGAC is an EPA presumptive remedy for VOCs (EPA, 1996) and is the most cost-effective VOC treatment technology given the conditions at the site. The evaluation indicated that ex situ biological treatment may be effective to achieve reinjection requirements for perchlorate. Therefore, the proposed remedial technique includes targeted mass removal using groundwater extraction, aboveground treatment using LGAC adsorption and FBR technology, and groundwater reinjection.

The objectives of the expanded treatability study are as follows:

- ❑ **Reduce Chemical Mass in the OU-1 Test Area.** The general test area (Figure 4-1) has been defined as the portion of the dissolved phase plume with VOC concentrations greater than 100 times the MCL and perchlorate concentrations greater than 400 µg/L. It is estimated that this 8-acre by 100-ft-thick portion of the site contains more than 68% of the dissolved plume chemical mass, but represents less than 3% of the volume of the dissolved chemical plume.
- ❑ **To Test, at Full Scale, the Most Cost-Effective Remedial Technique Identified for OU-1.** The expanded treatability study will allow for evaluation of the effectiveness of targeted mass removal via groundwater extraction, treatment, and reinjection. The expanded treatability study also will help to resolve several implementability issues related to groundwater reinjection.
- ❑ **Design a Flexible System that Could be Part of the Final Remedial Action for OU-1.** The treatability study is proposed in phases to provide an opportunity to collect additional data and to develop remediation and optimization strategies to support full-scale system implementation of the final OU-1 remedial action.

The expanded treatability study has been divided into two phases. Phase I involves the installation of one multilevel extraction well, installation of two injection wells, and use of existing monitoring wells in OU-1. Construction of the Phase I system is currently under way, and the anticipated start date for the system is late Fall/early Winter 2004. The extracted groundwater will be treated using the ex situ groundwater treatment train, consisting of LGAC adsorption, an FBR, aeration, and multimedia filtration. Phase II of the expanded treatability study tentatively involves expansion of the treatment system capacity and the installation of additional extraction and injection wells. A conceptual diagram of Phases I and II is shown on Figure 4-2.

Although cost-effective VOC treatment technologies are known (EPA, 1996), consensus on the best perchlorate treatment technologies is developing. Two primary aboveground methods for perchlorate treatment have emerged: FBR and ion exchange. The initial feasibility evaluation for OU-1 supports the use of an FBR to remove perchlorate from groundwater at NASA JPL. The primary advantages include: (1) a number of full-scale systems have been successfully implemented at other sites, (2) the technology was successfully demonstrated at the field-scale at NASA JPL, (3) biological treatment methods typically are less expensive in terms of capital and/or operation and maintenance (O&M) costs compared with ion exchange, and (4) perchlorate is destroyed rather than transferred to another media.

Results of the treatability study will be used in making the final decision regarding remediation in OU-1.

4.2.2 OU-2

Results of the OU-2 RI showed that VOCs were present in soil vapor beneath the JPL facility (FWEC, 1999b). The data indicated that carbon tetrachloride and TCE in soil vapor extended to the groundwater table beneath the north-central portion of the JPL facility, which is consistent with the on-facility groundwater plume identified in the OU-1/OU-3 RI (FWEC, 1999a).

A pilot-scale soil vapor extraction (SVE) system for OU-2, comprised of one soil vapor extraction well (VE-01) and vapor treatment using vapor-phase granular activated carbon (VGAC), was installed in April 1998. The pilot system demonstrated the effectiveness of SVE at JPL, removing more than 200 lb of VOCs by November 2001. Figures 4-3 and 4-4 depict the reduction in concentrations of perchlorate and TCE, respectively during operation of the pilot system, based on analytical data collected as part of the soil vapor monitoring program.

Based on the results of the pilot system and the evaluation conducted in the Feasibility Study, SVE was determined to be the most effective remedial alternative for removal of VOCs from vadose zone soil at JPL (NASA, 2002). The use of SVE at OU-2 is intended to enhance the overall site cleanup strategy by removing VOCs from the vadose zone, thus reducing a source of VOCs that may migrate to the groundwater. The extraction and treatment systems will be operated until VOCs in soil and vapor have achieved the system performance objectives as described in the Record of Decision (ROD) (NASA, 2002). The locations of vapor extraction wells, including the pilot system well and three additional wells, are shown in Figure 4-5. Full-scale implementation of the SVE system was initiated on September 30, 2003.

4.3 Other Source Protection Activities

Source protection activities are in progress at other potential sources identified in the source water assessment. These activities include:

- ❑ Efforts in La Cañada-Flintridge to obtain sanitary sewer connections at unsewered residences (potential sources of nitrate and PCE).
- ❑ MWD efforts to blend water from Northern California and the Colorado River to reduce perchlorate.
- ❑ California efforts associated with landfill/disposal areas.

4.3.1 La Cañada-Flintridge

The City of La Cañada-Flintridge is located in the San Gabriel Valley in the County of Los Angeles and is approximately 8.6 square miles in size (Willdan, 2003). This city is one of a few communities within the greater Los Angeles region that still relies on septic systems for sewage disposal. Of 6,989 homes in the area, only 2,218 units are served by a central sewage system, and many of the systems outside the central system are aged and failing (Willdan, 2003). The La Cañada-Flintridge Department of Public Works continues to receive numerous reports of septic overflows and failures annually. Septic overflows and system failures lead to sanitary and public health concerns, including the potential for contamination of drinking water supplies when sewage collects around water lines.

In 1997, La Cañada-Flintridge began to make sanitary sewer collection systems available to its residents, and construction of the sanitary sewer systems for the entire city is planned for completion by June 2008. A report describing the sewer collection system updates that are in progress for the city is entitled, *La Cañada-Flintridge Sewer Collection System – Areas 3A, 3B, 4, and 5 Draft Initial Study, Environmental Checklist, and Mitigated Negative Declaration*¹. Therefore, maintenance and overflow of private sanitary systems will be eliminated.

In addition to the sanitary and public health concerns of sewage overflow, the presence of PCE and elevated concentrations of nitrates in regional groundwater (e.g., Verdugo Basin, upgradient and along Foothill Boulevard) have been associated with historic uses of cesspools and septic systems (personal communication with DHS) in the La Cañada-Flintridge area. PCE was used as a septic system cleaner, whereas nitrates are byproducts of wastes contained within the septic systems.

4.3.2 MWD

Water from MWD is imported from Northern California and the Colorado River, with most of the water obtained from the Colorado River. Low levels of perchlorate were detected in the Colorado River and Lake Mead in 1997. A major perchlorate spill in 1997 by Kerr McGee Corporation impacted the Las Vegas Wash, a tributary to Lake Mead and the lower Colorado River. As reported by Dickerson (2003), initial concentrations in the Las Vegas Wash area were as high as 3,700,000 µg/L, and concentrations in Lake Mead were diluted down to 10 µg/L. Perchlorate levels in the lower Colorado River water now range from 4 to 9 µg/L (Dickerson, 2003).

In order to ensure perchlorate levels are below California's action level of 6 µg/L, MWD blends water from the Colorado River with water obtained from Northern California sources. Based on a 1999 public health assessment conducted by ATSDR (1999), it was determined that sampling and well water blending procedures used by the drinking water purveyors near JPL helped to prevent any potential present or future public health hazards posed by perchlorate in groundwater. Therefore, blending of water is an important preventive measure used by MWD to address water quality issues.

4.3.3 Former Landfills/Disposal Areas

At least three known former landfills/disposal areas and one active landfill are located within the Monk Hill Subarea. The inactive landfills are the Millard Cañon Dump, located on Cañon Crest Road; the Lincoln Debris Disposal area, located on Loma Alta Drive; and the solid waste facility at the Los Angeles County Public Works Maintenance district, located on West Mountain View Street. The active solid waste landfill is operated by the City of Pasadena Public Works and is located on West Mountain Street. This site is a limited volume transfer operation that accepts waste, including construction/demolition, green materials, and mixed municipal material. Additional information regarding years of operation, types and quantities of waste disposed, and landfill specific design (i.e., leachate collection system, monitoring, liners, caps, etc.) will be obtained and stated in the final report.

¹ This report can be downloaded from <http://www.lacanadaflintridge.com/city/docs/index.htm#eir>.

Municipal solid waste (MSW) landfills are subject to federal and state environmental regulations. Some of these regulations consist of operating criteria for landfills, test procedures for pollutants, and limitations in effluent and air emissions; a checklist summarizes pertinent federal and California environmental regulations². The California Integrated Waste Management Board has commissioned a unique, two-phase, cross-media study³ of the state's MSW landfills. Phase I of the study consists of a comprehensive, cross-media inventory and assessment of MSW landfill performance for the time period from January 1998 through December 2001. Phase II of the study consists of an assessment of the effectiveness of current regulatory requirements in controlling environmental impact over time. The study is the most comprehensive inventory ever undertaken of California landfills, involving multiple regulatory agencies in measuring the overall environmental effects of solid waste disposal in California.

4.4 Regulatory Communications Plan

The existing *Superfund Community Relations Plan* (NASA, 1994) and *Community Relations Plan – Amendment 1* (NASA, 2003c) describe the process that is currently in place to be used as a vehicle for which the DHS, City of Pasadena (PWP), LAWC, Rubio Cañon, and Las Flores water purveyors will be kept apprised of any new sources of chemicals in soil and/or groundwater that may potentially impact the source water of the Monk Hill Subarea.

The *Community Relations Plan* (CRP) for JPL was developed in 1994. The CRP is a formal plan for EPA community relation activities that occur at a Superfund site, which was developed in accordance with the EPA guidance *Community Relations in Superfund: A Handbook* (1992). The CRP summarizes the history of the site, identifies current community issues and concerns regarding the project, and summarizes site-specific activities to address these concerns. The CRP was reviewed and approved by the EPA Region 9, DTSC, and RWQCB. The community relation activities will be conducted in cooperation and close coordination with these agencies as described in the Federal Facility Agreement (FFA).

The purpose of the CRP is to lay out the mechanisms for informing and involving the public in activities and decisions related to the JPL site. Information Repositories created for local residents have been established at several locations:

JPL Library (JPL Employees Only)
Building 111, Room 104
(818) 354-4200

La Cañada-Flintridge Public Library
4545 Oakwood Avenue
La Cañada-Flintridge, CA 91011
(818) 790-3330

Altadena Public Library
600 E. Mariposa Street
Altadena, CA 91001
(626) 798-0833

Pasadena Central Library
285 E. Walnut Street
Pasadena, CA 91101
(626) 744-4052

The information repository also has been posted electronically, where files can be downloaded from the following Web site: <http://cercla.jpl.nasa.gov/NMOWeb/>.

² This report can be downloaded from <http://www.ciwmb.ca.gov/Publications/Facilities/52002002.pdf>

³ Information describing this study and preliminary results of this study can be downloaded from <http://www.ciwmb.ca.gov/Landfills/ComplyStudy/>.

The general purpose of the FFA is to ensure that the environmental impacts associated with past and present activities at the Facility are thoroughly investigated and appropriate remedial action is taken as necessary to protect the public health, welfare and the environment. In addition, the FFA establishes a procedural framework and schedule for developing, implementing, and monitoring appropriate response actions at the Facility in accordance with federal regulatory guidance and policy and applicable state law. Parties to this agreement include EPA Region 9, DTSC, RWQCB, and NASA. All parties are permitted to participate in a review and comment process for draft and final documents regarding investigation and cleanup activities at JPL. Communication among all parties is managed through monthly teleconferences, quarterly meetings, and discussions, as necessary, in between. More recently, participation in communication activities (i.e., document reviews, teleconferencing, and meetings) has been extended to DHS, the PWP, LAWC, Rubio Cañon, and Las Flores water purveyors on matters concerning OU-3 remedial action.

Therefore, both the CRP and FFA, which have already been established at the Facility, will be used to keep residents of the City of Pasadena, PWP personnel, and the DHS apprised of:

- ❑ Any new sources of chemicals in soil and/or groundwater
- ❑ Status of investigations occurring in the area
- ❑ Any new releases or other threats to groundwater
- ❑ Status of ongoing remediation activities
- ❑ Any other information impacting extraction wells.

In addition to these existing documents and information sources, a community outreach plan is currently being developed as another information vehicle to be used at JPL. This document is scheduled for completion in early 2004.

5.0 Effective Monitoring and Treatment

This section describes the approach that will be used to ensure that the water extracted from the four PWP drinking water supply wells (Ventura Well, Windsor Well, Arroyo Well, and Well 52), the two LAWC wells (#3 and #5), the two Rubio Cañon wells (#4 and #7), and the Las Flores well (#2) will undergo effective monitoring and treatment prior to domestic use.

Although VOCs and perchlorate are the primary chemicals of interest in the impaired source water, other parameters, such as inorganic compounds, also are considered when issuing a drinking water permit. The discussion of the effectiveness of the treatment and the monitoring plan is discussed in this section, along with a description of the treatment process, operations plan, and reliability features. In addition, information is provided on the notification plan and impaired source water quality surveillance plan.

5.1 Treatment System Description

The recommended PWP, LAWC, and Las Flores treatment systems consist of treatment and/or blending for VOCs and perchlorate prior to potable use by customers within the respective service areas. Currently there is no treatment necessary for the Rubio Cañon wells. However, if regular sampling of the water supply wells were to indicate that blending or centralized treatment is necessary, future treatment would be similar to that provided for the PWP, LAWC, and Las Flores wells. Details of the future blending plan or treatment system would be provided in the operating permit for the systems.

PWP Treatment System

The four PWP wells are situated southeast and downgradient of the JPL facility. As discussed in the City of Pasadena Water and Power Department's *Operation and Maintenance Procedures for the Devil's Gate VOC Groundwater Treatment Plant*, these wells will pump a combined total of up to 7,000 gpm. All groundwater extracted from these public water supply wells will flow through the PWP treatment systems prior to domestic use. Water samples will be collected consistently from the treatment plant influent, at intermediate points within the plant, and the plant effluent to monitor and optimize the process, in order to verify the effectiveness of treatment. A sampling schedule for PWP is provided as Table 5-1.

Centralized treatment for the PWP wells currently includes air stripping to remove VOCs. The proposed expanded system will also include ion exchange for perchlorate removal and LGAC, if necessary, to treat the effluent of the ion exchange system as a multibarrier control and additional protectiveness for both VOCs and perchlorate (EPA, 1996; Cannon and Na, 2000; AWWARF, 2001). A process flow diagram for this proposed treatment system is provided as Figure 5-1. The extracted groundwater will be conveyed from the wells to the existing VOC treatment system (air strippers) located near the Ventura Well. Treated water from the VOC treatment system will then be pumped to the ion exchange and LGAC treatment units, if necessary, which will be located at the Windsor Reservoir.

The first unit process of the PWP treatment system will be VOC removal using air strippers. The following description of the air stripping plant is from the City of Pasadena Water and Power Department Engineering Report, November 1999:

The air stripping plant is fed by two separate inflow pipes: one pipe carries water from Arroyo Well and Well 52, and the other pipe carries water from Ventura and Windsor Wells. The air stripping treatment system consists of two towers of identical design, each capable of treating a maximum flowrate of 3,750 gpm, which is the combined flow of Arroyo Well and Well 52, or a minimum flowrate of 1,160 gpm, which is the capacity of Windsor Well. This design uses a turn down ratio of 3.25 to 1. Each tower is 14 feet in diameter with a 40-foot bed depth of randomly dumped polypropylene packing. The overall height of each tower with the off-gas duct is approximately 50 feet. Each tower has a single centrifugal air blower capable of delivering air at a rate of 25,000 cubic feet per minute (cfm), at a static pressure of 18 inches of water column. This air-to-water ratio of 50 to 1 is considered adequate for treating the maximum flowrate of 3,750 gpm of water. The blower ductwork is interconnected so that either blower can deliver the required air rate to either tower.

The effluent from the air stripping towers flow by gravity into subsurface concrete sumps. The sumps are 8 feet deep and have a capacity of 35,000 gallons. Each of the vertical turbine transfer pumps is capable of delivering up to 3,500 gpm to Windsor Reservoir. One pump has a variable speed drive with a capacity that ranges from about 1000 gpm to 3500 gpm. The second pump has a fixed capacity of 3,500 gpm. The design of the pumps allows for at least 50% operation when one pump is down, and minimizes power consumption if the flowrate only requires one pump to be operated.

The off-gas from the air strippers is treated by passing through two 12-foot-diameter activated carbon beds (operated in parallel), each containing 11,500 pounds of carbon. The South Coast Air Quality Management District (SCAQMD) has issued a permit for both the carbon (Permit No. D67548) and for the air strippers (No. D67549).

The existing air stripping plant will be used as the primary VOC treatment process to reduce VOC concentrations. Influent (from the municipal wells) and effluent water and off-gas samples from the air strippers will be collected on a monthly basis to optimize the process and verify the effectiveness of VOC treatment. A detailed sampling plan is provided in Section 5.3.1 and Table 5-1 of this report.

As shown in Figure 5-1, following VOC treatment, the treated water then will be pumped through three parallel pairs of lead/lag ion exchange units for perchlorate removal. Ion exchange treatment will consist of a US Filter Model HP 1220DS Hi-Flow System (or equivalent; the vendor selection and procurement process will determine the actual ion exchange system)). The HP 1220DS System has two 12-ft-diameter ion exchange vessels (operated in a lead/lag configuration), with a nominal treatment capacity of 2,000 gpm and a maximum treatment capacity of 2,400 gpm. The empty bed contact time for the nominal treatment capacity is 3.76 minutes per vessel. All piping, valves, and gauges are included within the skid-mounted system. Details on the US Filter treatment system are provided as Attachment G, and include a summary of the technology, system specifications, and a general assembly diagram.

Each ion exchange unit will contain 300 cubic feet of Rohm and Haas, Amberlite™ PWA2 Strongly Basic Anion Exchange Resin (or equivalent; the vendor selection and procurement process will determine the specific resin), which is a specially designed resin for the selective removal of perchlorate from potable water. Amberlite™ PWA2 has been certified for potable water use according to National Sanitation Foundation (NSF) Standard 61 for drinking water

system components. Additional details on the ion exchange resin are provided in Attachment H.

If necessary, the final treatment process will include LGAC vessels for multibarrier control and additional treatment for both VOCs and perchlorate. The need for LGAC treatment will be determined based on monitoring of the air strippers and ion exchange units after the system is brought on-line. For the purposes of this application, it is assumed that eight vessels containing approximately 20,000 lb of granular activated carbon (GAC) each would be used if this treatment polishing step to ensure that the effluent VOC and perchlorate concentrations are below the DHS drinking water permit requirements. The LGAC vessels would be operated in a downflow parallel configuration, and each vessel would have a capacity of at least 900 gpm.

All treated water, which will be supplied for potable use, will be disinfected at the inlet to Windsor Reservoir.

LAWC Treatment System

The two LAWC wells also are situated southeast and downgradient of the JPL facility. These wells pump a combined flow of approximately 2,000 gpm. All groundwater extracted from these public water supply wells flow through the existing LAWC treatment system prior to potable use. Water samples are collected consistently from the treatment plant influent, at intermediate points within the plant, and the plant effluent to monitor and optimize the process, in order to verify the effectiveness of treatment. A more detailed sampling plan is provided in Section 5.3.1 and Table 5-2 of this report.

Centralized treatment for the LAWC wells includes ion exchange to remove perchlorate and LGAC to remove VOCs. A process flow diagram for this treatment system is provided as Figure 5-2. Ion exchange treatment consists of a US Filter Model HP 1220DS Hi-Flow System. The HP 1220DS System has two 12-ft-diameter ion exchange vessels (operated in lead/lag configuration), with a nominal treatment capacity of 2,000 gpm and a maximum treatment capacity of 2,400 gpm. The empty bed contact time for the nominal treatment capacity is 3.76 minutes per vessel. All piping, valves, and gauges are included within the skid-mounted system. Details of the US Filter treatment system are provided as Appendix G, and includes a summary of the technology, system specifications, and a general assembly diagram.

Each ion exchange unit contains 300 cubic feet of Rohm and Haas, Amberlite™ PWA2 Strongly Basic Anion Exchange Resin, which is a specially designed resin for the selective removal of perchlorate from potable water. Amberlite™ PWA2 has been certified for potable water use according to NSF Standard 61 for drinking water system components. Additional details on the ion exchange resin are provided in Appendix H. Weekly samples are collected for perchlorate analysis after the lead ion exchange unit to confirm that the DHS permitting requirements are met and to allow for optimization of the unit process.

The next unit process of the LAWC treatment system is VOC removal using LGAC vessels. Four vessels containing approximately 20,000 lb of GAC each are used to treat VOCs in the extracted groundwater to levels below the DHS drinking water permit requirements. Each vessel has a capacity of up to 900 gpm; however, the normal operating capacity of the units is 700 gpm. The four vessels are operated in a downflow parallel configuration. Monthly influent and effluent water samples to the LGAC unit process are collected to confirm that the DHS permitting requirements are met and to allow optimization of the unit process.

All water treated from the LAWC treatment system is continuously and reliably chlorinated to a minimum of 0.2 ppm. The chlorinated water is monitored daily before it reaches the first customer in the distribution system. The treated water is conveyed from the LAWC treatment system to the Olive Avenue Sump. At the Olive Avenue Sump the treated water is blended with water supplied by the Foothill Municipal Water District (FMWD). The blending adds another level of redundancy to the treatment process to ensure water provided for potable use meets the DHS permitting requirements at all times.

Rubio Cañon Treatment System

The two Rubio Cañon wells pump a total of approximately 2,700 gpm; Well #4 pumps approximately 900 gpm, and Well #7 pumps approximately 1800 gpm. Water from the wells is blended with water from FMWD in the blending sump prior to distribution. All water is chlorinated at the blending sump prior to being supplied for potable use.

As mentioned earlier, treatment for the Rubio Cañon wells is not currently necessary. Water from the wells is monitored regularly for perchlorate. As requested by DHS in a letter dated May 28, 2004, if the concentration of perchlorate exceeds the DHS action level of 6 ppb, a formal blending plan will be prepared and submitted to DHS for review and approval. Customers will be notified if blending to reduce perchlorate levels is required. If the concentration of perchlorate exceeds three times the DHS action level (i.e., greater than 18 ppb), then treatment to reduce the perchlorate concentrations will be required. Details of the selected treatment system would be submitted for review and approval by DHS at that time.

Las Flores Treatment System

Las Flores Well #2 pumps approximately 400 to 500 gpm. All groundwater extracted from this public water supply well will flow through the Las Flores treatment system prior to domestic use. Water samples will be collected consistently from the treatment plant influent, at intermediate points within the plant, and the plant effluent to monitor the effectiveness of treatment and optimize the process. A more detailed sampling plan for Las Flores is provided in Section 5.3.1 and Table 5-3.

Centralized treatment for the Las Flores well includes one LGAC vessel and blending. The LGAC vessel has a maximum design capacity of 750 gpm and is used to treat PCE in the extracted groundwater to levels below the DHS drinking water permit requirements. The treated groundwater is then blended with water from FMWD at the blending sump to reduce the concentration of perchlorate below the action level prior to distribution. An approved blending plan for the Las Flores Water Company is on file with DHS. The blending also adds another level of redundancy to the VOC treatment process to ensure water provided for potable use meets the DHS permitting requirements at all times. All treated water will be chlorinated prior to being supplied for potable use, and daily chlorine residual levels will be measured and recorded.

5.2 Performance Standards

Overall performance of the treatment systems will be measured by samples collected from the finished water. Sampling will be conducted in accordance with CCR Title 22. DHS may modify the Title 22 requirements or request additional monitoring, which would be outlined in the operating permit. State MCLs and ALs are primarily the controlling standards for the finished

water, and these standards must be attained for the effluent from the PWP, LAWC, and Las Flores treatment plants. However, DHS has required that the LAWC treatment system remove perchlorate in the finished water to less than detection using EPA Method 314. A listing of constituents to be monitored, analytical methods, reporting limits, MCLs, ALs, PHGs, and monitoring frequencies is provided in Section 5.4.2, Compliance Monitoring and Reporting Program. The monitoring program outlined in Section 5.4.2 assures that treated and blended water will meet or exceed application Title 22 water quality criteria.

If at any time the analytical results for any of the treatment plant effluent water samples are not in compliance with DHS requirements, that treatment plant will be manually shut down by the operator. The operational records and set points will be reviewed so that a cause for the noncompliance can be identified and communicated to DHS. The treatment plant will be restarted after DHS approves the modifications and corrective actions proposed by the operator.

5.3 Operations Plan and Reliability Features

Each of the treatment systems includes use of the best available technologies defined for the chemicals of interest. The O&M Plans are designed to optimize operation of the treatment systems to achieve the lowest concentration of contaminants feasible at all times. The entire flow from the water supply wells passes through the treatment systems at all times.

5.3.1 Process Monitoring and System Reliability

Performance of individual unit processes will be monitored to ensure that the treatment plants are operating properly and continually meeting the DHS permitting requirements.

PWP Treatment System

The O&M plan for the existing VOC treatment plant is included as Appendix I to this document. Design of the ion exchange and LGAC components of the treatment system is currently ongoing; therefore, O&M plans for this part of the system are not yet available. Once a vendor is selected, an O&M plan will be developed for these treatment system components and included as an attachment to this document.

As discussed in Section 5.1, the existing VOC treatment plant consists of two packed tower air strippers with VGAC off-gas treatment. The VOC treatment plant is equipped with a control panel to control the mechanical equipment and shut down the treatment system in the event of a power failure, a blower shutdown, a high sump level, or a low sump level (Note that the existing control system for the VOC plant may require physical improvements. For example, if the fan belt for the blower breaks, the motor may continue to operate without triggering the control system to shut the plant off; thus water will continue to flow through the air strippers without removing VOCs). The equipment interlocked with the control panel are the well pumps, the air stripper blowers, and the effluent booster pumps. A complete list of the alarms and control mechanisms is provided in the O&M manual (see Appendix I).

In addition to the automatic monitoring and shut down mechanisms, daily inspections will also be conducted by the Treatment Plant Operator. The daily operational records for the VOC treatment plant will include, at a minimum, operational flowrates from the four wells and

between each treatment plant unit process; total volume treated; air-to-water ratios; operational changes; and unusual occurrences or shutdowns. An example daily inspection report form is included in the O&M plan in Appendix I. If any instrumentation is malfunctioning to the point where proper operation of the plant cannot be assured, then the plant will be shut down. A monthly report containing these records will be submitted to the DHS.

Regular O&M of the treatment system also will include sampling to confirm treatment system effectiveness; a sampling schedule for the PWP treatment system is shown in Table 5-1. Off-gas samples from the air strippers will be collected after each carbon unit on a monthly basis. When sampling results indicate that breakthrough has occurred, the activated carbon media in that unit will be replaced on site and the spent media will be taken off site for disposal or regeneration by a carbon service.

Weekly treated water samples will be collected for perchlorate analysis after each of the lead ion exchange units. The ion exchange resin will be replaced in the lead vessel when the effluent perchlorate from the lead vessel reaches a concentration of 30% of the influent perchlorate concentration, or if the perchlorate concentration leaving the lag vessel exceeds the detection limit of 4 µg/L. During the resin change, the lead vessel will be taken off line and new resin will be loaded into the vessel. The vessel containing the new resin will be placed in the lag/polishing position. Valving will be adjusted so that the former lag vessel will take the lead position. This will ensure that the newest resin is always in the lag/polishing position.

Similarly, if LGAC vessels are necessary, weekly samples (for VOCs and non-VOCs such as 1,2,3-TCP, SVOCs, NDMA, 1,4-dioxane, and explosives [TNT, RDX, and HMX]) from the 4th port on each LGAC vessel would be collected to determine when activated carbon replacement is necessary. The GAC would be replaced in the individual vessels when a breakthrough of VOCs or any of the non-VOCs occurs, as indicated by samples obtained from the 4th port located at approximately 75% of the depth of the LGAC bed. The spent media would be taken off site for disposal or regeneration by a carbon service.

In addition, coliform and/or heterotrophic plate count (HPC) testing will be performed from the final effluent of each lag vessel. When the effluent from an individual vessel tests positive for coliform and/or the HPC exceeds 500 CFU/mL, that vessel will be re-tested within 24 hours. Consideration for disinfection of the vessel(s) will be given if there are two consecutive positive results for coliform and/or the HPC tests which exceed 500 CFU/mL.

Reliability features of the PWP treatment plant will include the following:

- Automated monitoring and control of the air strippers ensures consistent treatment of the extracted water, and automatic shutdown of the treatment system in the event of a power failure, a blower shutdown, a high sump level, or a low sump level.
- Operation of multiple LGAC vessels and pairs of ion exchange vessels in parallel will ensure that the plant will not need to be shut down if one vessel fails or is out of service. This level of redundancy allows operation of the plant to continue at a lower flowrate when carbon or resin becomes spent and needs to be replaced.
- Weekly sampling of the ion exchange and LGAC systems will ensure that the treatment system is achieving the DHS permitting requirements at all times.

- Implementation of a blending program provides additional reliability and reduces the presence of inorganic and metal compounds to levels below those required by DHS.

LAWC Treatment System

The O&M plans for the LAWC treatment system are included as Appendix J to this document. The treatment plant raw water flow is approximately 2,000 gpm. Specific design criteria and operating parameters and guidelines for each process of the treatment plant are provided in the O&M Plans.

As discussed in Section 5.1, the LAWC treatment plant consists of ion exchange and LGAC vessels. Daily inspections of the treatment system will be conducted by the Treatment Plant Operator. The daily inspections will be recorded on a log sheet and will include the pressure drop across the ion exchange units and the LGAC units, all equipment maintenance, calibrations, system cleaning, repairing, parts replacement, and unusual occurrences or shutdowns. A monthly report containing these records will be submitted to the DHS.

Regular O&M of the treatment system also will include sampling to confirm treatment system effectiveness; a sampling schedule for the LAWC treatment system is shown in Table 5-2. Weekly treated water samples will be collected for perchlorate analysis after each of the ion exchange units. The ion exchange resin will be replaced in the lead vessel when the effluent perchlorate from the lead vessel has reached a concentration of 30% of the influent perchlorate concentration, or if the perchlorate concentration leaving the lag vessel exceeds the detection limit of 4mg/L. During the resin change, the lead vessel will be taken off line and new resin will be loaded into the vessel. The vessel containing the new resin will be placed in the lag/polishing position. Valving will be adjusted so that the former lag vessel will take the lead position. This will ensure that the newest resin is always in the lag/polishing position.

Similarly, weekly VOC samples from the 4th port on each LGAC vessel will be collected to determine when activated carbon replacement is necessary. The GAC will be replaced in the individual vessels when a breakthrough of VOCs occurs, as indicated by samples obtained from the 4th port located at approximately 75% of the depth of the LGAC bed. The spent media will be taken off site for disposal or regeneration by a carbon service.

In addition, monthly microbiological testing (coliform and HPC) of the combined effluent from the treatment plant will be conducted. If the combined effluent sample tests positive for coliform and/or the HPC exceeds 500 CFU/mL, each LGAC and ion exchange vessel will be tested. When the effluent from an individual vessel tests positive for coliform and/or the HPC exceeds 500 CFU/mL, that vessel shall be re-tested within 24 hours. Consideration for disinfection of the vessel(s) shall be given if there are two consecutive positive results for coliform and/or the HPC tests which exceed 500 CFU/mL.

Reliability features of the LAWC treatment plant include the following:

- Operation of multiple LGAC vessels in parallel will ensure that the plant will not need to be shut down if one vessel fails or is out of service. This level of redundancy allows operation of the plant to continue at a lower flowrate when carbon becomes spent and needs to be replaced.

- Each LGAC vessel is designed to provide a contact time of 6 minutes at a maximum flowrate of 900 gpm each. However, LAWC operates the LGAC units with an average flowrate of 700 gpm for a 7.5-minute contact time. This additional contact time provides an added level of safety to ensure that VOC contaminants are removed from the drinking water.
- Weekly sampling of the ion exchange and LGAC systems will ensure that the treatment system is achieving the DHS permitting requirements at all times.
- Treated water is discharged to the Olive Sump and, when demand dictates, blended with water purchased from FMWD. The blending adds another level of protectiveness to the treatment process to ensure clean, safe water is provided to LAWC customers.

Las Flores Treatment System

As discussed in Section 5.1, the LAWC treatment plant consists of one LGAC vessel. The DHS permit, including operational requirements for the Las Flores treatment system, is included in Appendix K. Process monitoring points at the Las Flores treatment system include influent water from the well, sampling ports at 50% and 75% of the LGAC bed depth, after the LGAC unit, and after the blending operations. A detail sampling schedule is provided in Table 5-3. Results of this sampling will be used to determine when breakthrough occurs in the LGAC units, and to optimize the blending operations. The activated carbon in the vessel will be replaced when breakthrough of PCE is detected at the sample tap at 75% of the depth of the LGAC. AQUACARB 830 will be used when replacing the activated carbon, or DHS approval will be obtained to use other replacement carbon. If any GAC in the vessel is replaced with reactivated GAC, the GAC will be reactivated according to the DHS Policy 94-005, "Use of Reactivated Carbon for Drinking Water Treatment".

Daily inspections of the treatment system will also be conducted by the Treatment Plant Operator. The daily inspections will be recorded on a log sheet and will include the flowrate, total volume treated, chlorine residual measurements, pressure drop across the LGAC unit, all equipment maintenance, calibrations, system cleaning, repairing, parts replacement, and unusual occurrences or shutdowns. A monthly report containing these records will be submitted to the DHS.

Reliability features of the PWP treatment plant will include the following:

- Weekly sampling of the LGAC vessel will ensure that the treatment system is achieving the DHS permitting requirements at all times.
- Implementation of a blending program provides additional reliability and reduces the presence of perchlorate and other inorganic and metal compounds to levels below those required by DHS.

5.3.2 Plant Optimization

Plant optimization is a process by which the operation of the treatment plant is fine-tuned to obtain maximum performance. The two primary goals of plant optimization are to: (1) meet or exceed the performance standards; and (2) provide the most cost-effective method for treatment. In general, optimization will most likely focus on adjustments to treatment system

influent flowrates to the LGAC and ion exchange units, the air-to-water ratio in the air strippers, and water blending ratios.

Adjustments of the air to water ratio in the air strippers will be made if necessary to optimize performance. Airflow will be adjusted through the use of variable speed motors on the air blowers to obtain the optimum air to water ratio in the air strippers. Optimization considers the cost of operation, but will not replace the operational performance standards specified for the treatment process. Optimization may include varying the airflow rate to determine the impact on water quality, LGAC usage, and power consumption. Decisions regarding the change-out of the LGAC and ion exchange resin in each of the treatment systems will be made based on protecting the domestic water supply.

Optimization of blending also will occur at the respective reservoirs. The ratio of treated process water and MWD/FMWD water during blending will be adjusted in order to reduce the presence of chemicals that are not treated by each of the plants.

5.3.3 Failure Response

As discussed above, the PWP VOC treatment plant is equipped with a control panel to control the mechanical equipment and shut down the treatment system in the event of a power failure, a blower shutdown, a high sump level, or a low sump level. The pieces of equipment interlocked with the control panel are the well pumps, the air stripper blowers, and the effluent booster pumps. In addition, if any instrumentation is malfunctioning to the point where proper operation of the plant cannot be assured, then the plant will be shut down.

In addition, each system is monitored daily by the Treatment System Operator. If major components of any the systems are not operational (e.g., wellhead pumps, air stripper blowers, LGAC backwash system) or if any instrumentation is malfunctioning to the point where proper operation of the plant cannot be assured, then the treatment plant will shut down. Also, if any of the treatment systems fails to achieve the DHS permitting requirements, it will be shut down. Failure response and risks associated with a treatment system failure are discussed in detail in Section 6.0.

Where DHS approval exists, treatment plant effluent for potable use will be transferred to the respective reservoirs for blending with MWD/FMWD water to reduce the concentration of nitrates and other compounds not removed by the treatment system before the water is introduced into the domestic water distribution system. Should the blending operation fail or be unable to reduce the concentrations below the required levels, the blending operations will cease, and the water purveyor will immediately notify DHS, and customers will be notified of the failure.

5.4 Treatability Assessment and Monitoring Program

A monitoring program will be implemented upon the startup of the treatment plants in order to assure protection of the domestic water supply (see Section 5.4.2). Because the raw water originates from an extremely impaired source, monitoring required under CCR Title 22 will be

performed in addition to monitoring compounds identified during the source water assessment and raw water quality characterization. All compounds identified in the raw water quality characterization will be assessed for treatability as described in Section 5.4.1. A monitoring program is defined based on the results of the treatability assessment and the monitoring requirements from 22 CCR 15. However, the monitoring program may be amended by DHS permit conditions (i.e., frequency and compounds), or changed in the future to satisfy changing site conditions. Additional compounds may be assessed and added to the monitoring program, as necessary, if they are discovered in the future.

5.4.1 Treatability Assessment

COPCs for each of the production wells were identified in Section 3.5 using monitoring well data and reported chemical usage data (see Table 3-20). The treatability assessment evaluates the potential of each treatment system to meet performance standards for the COPCs based on chemical and physical properties. The compounds listed in Table 5-4 were evaluated for their ability to be treated by either the air stripper (volatility), LGAC (adsorbability), or ion exchange, as appropriate. A constituent is considered treatable using ion exchange based site-specific breakthrough curves provided by the ion exchange vendor. A constituent is considered treatable by the air strippers if its dimensionless Henry's law constant is equal to or greater than 0.01 (EPA, 1996).

A constituent is considered adsorbable using activated carbon if it is characterized as an average or good adsorber using the criteria of 4 mg/g for a 1 mg/L solution developed and presented by Calgon Corporation in the Advanced Oxidation Treatment (AOT) Handbook. Information regarding 1,2,3-TCP, TNT, and RDX was not available from the AOT Handbook; therefore, additional sources were consulted, including the Federal Remediation Technology Roundtable guidance, and the Draft Groundwater Information Sheet for 1,2,3-TCP prepared by the California State Water Resources Control Board.

The physical properties and references used in the treatability assessment are provided as Appendix L to this document along with a treatability assessment Table. Using the criteria established for the treatability assessment, the list of compounds in Table 5-4 was developed to differentiate between "compounds treatable by plant" and "compounds potentially not treatable by plant."

5.4.2 Compliance Monitoring and Reporting Program

The wells and treatment plants will be monitored in accordance with CCR Title 22 Chapter 15 and with any additional DHS permit requirements. Tables 5-1 through 5-3 summarize the constituents to be analyzed and the monitoring frequency. The frequency of monitoring for COPCs will be defined in the DHS permit conditions. All identified COPCs will be monitored. ALs and MCLs for organic compounds will be met in the treated water, except for perchlorate which will be non-detect using EPA Method 314. Water supply well sampling will be performed to monitor chemicals of interest. Additionally, samples will be collected from various other locations throughout each treatment plant to monitor and optimize the water treatment plant process, as discussed above. Nitrate concentrations will be monitored at the

reservoir pump stations. Constituents not expected to be removed by the treatment plant will be monitored and controlled by blending with MWD/FMWD water at the reservoirs.

A summary report will be prepared and submitted to the DHS and EPA on a monthly basis for each treatment plant. The report will include the quantity of water extracted from each well, the total flowrate for each treatment system, and operational parameters for each treatment system. A summary of analytical results, including monitoring well samples, process monitoring samples, and blended water samples, will be included in the report. Any abnormal conditions or treatment system maintenance also will be included in the summary report.

Target compounds for an analytical method are the compounds that are identified as applicable to that specific method. However, additional compounds, referred to as non-target compounds, also may be detected by the method. If the concentration of a non-target compound is sufficient enough to produce a signal greater than or equal to the set peak threshold, a library search will be performed by the laboratory to determine tentative identification. If the non-target compound matches a compound listed in the library, it is then referred to as a tentatively identified compound (TIC). Reporting requirements for non-target VOCs and SVOCs are included in the DHS guidance that was revised in September 2003. The reporting of these compounds should be conducted by the water purveyor per DHS guidance.

5.5 Water Quality Surveillance Plan

The water quality surveillance plan identifies that results from the ongoing quarterly groundwater sampling conducted for the JPL monitoring wells will be reviewed to provide early detection of increasing chemical concentrations. Note that all of the water supply wells are located downgradient of the former source of chemicals on JPL property. This physical arrangement will likely result in the water quality surveillance plan discovering higher chemical concentrations as system operation continues. The treatment capacity of the plant will be designed to handle the potential increase in chemical concentrations. As system operation progresses, fate and transport analysis of data collected from upgradient monitoring wells will be evaluated to estimate concentrations in the water supply wells. This evaluation will be completed to verify that the treatment capacity of each plant is sufficient to address potentially increasing concentrations of chemicals.

The water quality surveillance plan will be incorporated into the current JPL groundwater monitoring program that was initiated in August 1996. The groundwater monitoring program includes VOCs and inorganics, including metals, anions, cations, and other field parameters. Analyses for metals, anions, cations, alkalinity, and pH have been performed annually in recent years. Some of the chemicals analyzed in this program include carbon tetrachloride, TCE, PCE, 1,1-DCA, 1,1-DCE, Freon 113, chloroform, and perchlorate. The water quality surveillance plan will include the same constituents as the groundwater monitoring program. The surveillance plan may be amended to include additional constituents, as required by the DHS.

5.6 Emergency Notification/Contingency Plan

All emergency situations will be reported by verbal communication to management and the appropriate regulatory agencies as soon as possible. Emergency situations can be defined as

operation incidents, compliance failure for treated water, pipeline leaks or breaks, natural disasters, and safety and health incidents (i.e., accidents, injuries, spills, releases). In the event of an emergency situation, management of the respective treatment system will notify the DHS, EPA, and the public.

In an emergency situation, the following emergency interconnections are available for each water company:

- PWP has a total of 27 interconnections with seven other local water systems that can supply water during emergencies, shortages, or periods of high demand. Approximately 22 of the interconnections are supplied by other water agencies to provide water to the City for emergency and general services. It should be noted that the majority of the interconnections permit flow only in one direction either due to differences in static pressure, or back flow devices.
- LAWC maintains three emergency interconnections including water obtained from Las Flores and two locations from PWP.
- Las Flores maintains one emergency interconnection with LAWC.
- Rubio Cañon maintains one emergency interconnection with PWP.

6.0 Risks Associated with the Failure of the Treatment System

6.1 Introduction

Groundwater treatment technologies are not failure-proof, and untreated or insufficiently treated water can pass through treatment systems and into distribution systems. Therefore, an assessment was conducted to evaluate the potential health risk associated with such failures. This assessment includes an estimation of the risks of failure of the proposed treatment systems, and an assessment of potential health risks associated with potential failure of the proposed treatment systems. The estimation of the risks of failure is evaluated in terms of the probability to fail, thereby resulting in exposure of individuals to insufficiently or untreated drinking water. The health assessment takes into account the duration of exposure resulting from the potential failure, the human health risks associated with such failure resulting from exposure to microbiological and chemical constituents, and the cumulative risks due to potential multiple failures of the treatment systems.

6.2 Background

As described in Section 5.0, four drinking water purveyors operate using groundwater from the Monk Hill Subarea: PWP, LAWC, Rubio Cañon, and Las Flores. Drinking water treatment at the PWP treatment plant includes air stripping for VOC removal, ion exchange for perchlorate treatment, and LGAC as a polishing step. The LAWC treatment system consists of LGAC for VOC removal and ion exchange for perchlorate treatment. The Las Flores treatment system consists of LGAC for VOC removal and blending for perchlorate concentration reduction. Currently, no centralized treatment is required for the Rubio Cañon drinking water supply wells. Treated water from PWP, LAWC, and Las Flores will be available to their respective customers within the City of Pasadena and Altadena for potable use upon approval from the DHS. Rubio Cañon is included in this permit application in the event that centralized treatment becomes necessary in the future.

As discussed in Section 5.0, process flow diagrams of the PWP and LAWC treatment systems are presented in Figures 5-1 and 5-2, respectively. Interlocks and other instrumentation and controls are designed into each system to protect against accidental discharge of untreated water from the PWP treatment system to the municipal water supply by initiating automatic shutdown if specific parameters are not met. All systems also are monitored on a daily basis by the Treatment Plan Operator to determine if there are any operating parameters out of range, or unusual operational problems. System redundancy also will be provided for the important equipment such as parallel operation of air strippers, ion exchange units, and LGAC vessels. Preventative measures that will be taken specifically for each of the treatment systems are described in following subsections.

6.2.1 PWP Treatment System

The PWP drinking water treatment system will consist of several components including groundwater extraction pumps, air strippers for VOC removal, ion exchange for perchlorate removal, and LGAC for polishing treatment, if necessary. Because equipment failure or other adverse conditions potentially may impact treatment effectiveness, the following preventative measures will be taken to shut down the treatment system upon equipment failure in order to minimize the potential impact to human health and to prevent the delivery of untreated groundwater to the public:

- ❑ The treatment system controls will automatically shut down the system if any of the following occurs: power failure, air stripper blower shut down, high pressure in the air stripper, low pressure in the air stripper, high air stripper sump level, or low air stripper sump level.
- ❑ The treatment system will be manually shut down if the Treatment System Operator identifies that any operating parameter, for example the pressure buildup in the LGAC vessels or the ion exchange vessels, is out of the recommended operating range.
- ❑ The treatment system will be manually shut down if any COPCs are detected above the permitted limits during the regularly scheduled monitoring events.

6.2.2 Lincoln Avenue Water Treatment System

The LAWC drinking water treatment system consists of groundwater extraction pumps, ion exchange for perchlorate removal, and LGAC for VOC removal. Because equipment failure or other adverse conditions potentially may impact treatment effectiveness, the following preventative measures will be taken to shut down the treatment system upon equipment failure to minimize the potential impact to human health and to prevent the delivery of untreated groundwater to the public:

- ❑ The treatment system will be manually shut down if the Treatment System Operator identifies that any operating parameter, for example the pressure buildup in the LGAC vessels or the ion exchange vessels, is out of the recommended operating range.
- ❑ The treatment system will be manually shut down if any COPCs are detected above the permitted limits during the regularly scheduled monitoring events.

6.2.3 Las Flores Treatment System

The Las Flores treatment system consists of groundwater extraction pumps, LGAC for PCE removal, and blending for perchlorate concentration reduction. Because equipment failure or other adverse conditions potentially may impact treatment effectiveness, the following preventative measures will be taken to shut down the treatment system upon equipment failure to minimize the potential impact to human health and to prevent the delivery of untreated groundwater to the public:

- ❑ The treatment system will be manually shut down if the Treatment System Operator identifies that any operating parameter, for example the pressure buildup in the LGAC vessels or the ion exchange vessels, is out of the recommended operating range.
- ❑ The treatment system will be manually shut down if any COPCs are detected above the permitted limits during the regularly scheduled monitoring events.

6.3 Summary of Results

6.3.1 Evaluation of Potential Failure Scenarios and Frequency of Occurrence

System performance will be monitored by various interlocks and other electronic instrumentation and controls in order to protect against accidental discharge of untreated water to the municipal water supply. However, a worst-case scenario was assumed in order to determine the health risks to users from untreated groundwater if a complete and simultaneous failure of system components were to occur (even though the programmable logic controller would still be in operation). Under this failure scenario, all preventative measures as listed above for each treatment system would have been impeded enough for problems to go unnoticed for a lengthy period of time, resulting in using untreated water for potable purposes.

As discussed in Section 5.3.1, PWP, LAWC, and Las Flores collect weekly treatment system monitoring samples. System failure is assumed to occur immediately following collection of a weekly treated water sample. The failure therefore would not be detected, and thus resolved, for a total of 14 days, assuming the next scheduled sampling event would be in seven days and laboratory turnaround time for analyses is seven days. Complete failure of the treatment system is conservatively assumed to occur once every five years over a 20-year period.

6.3.2 Health Risk Evaluation

An assessment of the water quality of the influent to each of the treatment plants was performed in Section 3.0. Based on the results of this assessment, chemicals and estimated concentrations of these chemicals were used to conduct the health risk evaluation. Estimated influent concentrations of COPCs (Table 3-20) were used to calculate carcinogenic risk (risk) and noncarcinogenic hazard (hazard) estimates associated with exposure to untreated water. Risk and hazard estimates were calculated by using ratios of COPC concentrations to health-based drinking water standards. Three types of standards were used:

- ❑ California Office of Environmental Health Hazard Assessment (OEHHA) PHGs were used for carcinogens and noncarcinogens when a PHG existed. For PHGs based on cancer risk, the PHG was assumed to represent a concentration associated with a cancer risk of one in one million (i.e., 1×10^{-6}). For PHGs based on noncancer effects, the PHG was assumed to represent a safe threshold above which adverse health effects might result. The supporting documentation for development of PHGs for cancer causing chemicals also was consulted in order to obtain the noncancer PHG.

- ❑ California MCLs and ALs were used as applicable standards for COPCs without PHGs. Again, for MCLs/ALs based on cancer effects, it was assumed that the concentration represented a cancer risk of one in one million (i.e., 1×10^{-6}). For MCLs/ALs based on noncancer effects, the standard was assumed to represent a safe threshold above which adverse health effects might result.
- ❑ EPA Region 9 PRGs also were used for COPCs without PHGs or MCL/AL. In addition, the PRG was used as the cancer and/or noncancer applicable standard if it was lower than the MCL/AL. Similarly, it was assumed that the PRG concentration for carcinogens represented a cancer risk of one in one million (i.e., 1×10^{-6}) and for noncarcinogens represented a safe threshold value.

Rather than conduct a risk assessment for these COPCs under a treatment failure scenario, a more streamlined risk evaluation was conducted that used risk ratios to estimate carcinogenic risks and noncarcinogenic indices. The use of the PHG in this particular evaluation was intended to be conservative because the PHGs are strictly risk-based (i.e., levels that provide protection against cancer and noncancer health effects associated with exposure to that chemical), and do not consider technical feasibility or cost to implement, as do MCLs. Therefore, concentrations of COPCs identified in each of the water treatment system's effluent was compared with a PHG (if one existed) to obtain a risk estimate.

The cancer risk associated with COPCs in untreated drinking water is calculated using equation 6-1. Risk estimates are presented as excess cancer risk per unit of population. For example, a risk estimate of 1×10^{-6} is equivalent to one excess occurrence of cancer per 1,000,000 individuals in a given population.

$$\text{Cancer Risk} = \frac{\text{COPC Concentration}}{\text{Cancer Applicable Standard}} \times \frac{\text{Period of Exposure in days}}{70 \text{ years} \times 365 \text{ days per year}} \times 10^{-6} \quad (6-1)$$

The potential for adverse noncarcinogenic effects from chemical exposure is expressed in terms of the hazard quotient (HQ). The HQ is the ratio of the estimated dose that a human receives to the estimated dose level believed to be safe, the applicable standard. The chemical-specific HQ values are summed across all COPCs to determine the total site noncancer hazard index (HI). If the HI value is less than 1.0, it is believed the risk of noncarcinogenic effects is low. If the HI exceeds 1.0, a potential for some noncarcinogenic effects may exist. However, because the applicable standards are derived in a conservative fashion, an HI value greater than 1.0 does not imply that an adverse effect will necessarily occur. The HQ was calculated using equation 6-2.

$$\text{HQ} = \frac{\text{COPC Concentration}}{\text{Noncancer Applicable Standard}} \quad (6-2)$$

Where:

COPC Concentration	=	estimated arithmetic mean of the influent (Table 3-20);
Applicable Standard	=	PHG or MCL/AL or PRG
Period of Exposure	=	56 days
Average Lifetime	=	70 years (carcinogenic effects are averaged over a lifetime).

Assumptions for risk/hazard calculations are:

1. COPC concentrations in groundwater are assumed to remain constant over the duration of exposure (i.e., 20 years);
2. No dilution or attenuation of the concentration is expected to occur prior to ingestion at the tap by the consumer;
3. The number of days untreated water is released from the treatment plant is 14 and treatment fails on four separate occasions (i.e., total of 56 days) over a 20-year period;
4. Carcinogenic effects are not based on a threshold, as are noncancer effects, and are averaged over a lifetime of exposure.

Risk and hazard estimates for the site are compared with the EPA *de minimus* cancer risk criterion of 1×10^{-6} and hazard index of 1.0. Estimates of the cancer risk and noncancer hazard index are provided in Tables 6-1 through 6-4 for each of the COPCs identified in the water treatment plant influent estimates. As summarized in Table 6-1 for the influent to the water treatment plant for the Arroyo Well and Well 52, the cumulative cancer risk (i.e., summation of risk across COPCs) is 8.0×10^{-8} , which is less than the 1×10^{-6} *de minimus* risk level. However, the HI is above 1.0 (HI=4.0). The primary chemical resulting in the excess HI is perchlorate with a HQ of 3.4.

For the influent to the water treatment plant for the Ventura and Windsor Wells (Table 6-2), HI is less than 1.0 (HI=0.7).

For the influent to the water treatment plant for the LAWC wells (Table 6-3), the cumulative cancer risk (i.e., summation of risk across COPCs) is 4.2×10^{-8} , which is less than the 1×10^{-6} *de minimus* risk level. However, the HI is above 1.0 (HI=2.1). The HQ for perchlorate is 2.0.

For the influent to the water treatment plant for the Las Flores well (Table 6-4), the cumulative cancer risk (i.e., summation of risk across COPCs) is 3.8×10^{-7} , which is less than the 1×10^{-6} *de minimus* risk level. However, the HI is above 1.0 (HI=2.9). Noncancer HQs for nitrate and perchlorate are 1.0.

The calculated health risks (Tables 6-1 through 6-4) indicate that incremental cancer risks are in line with the accepted EPA criterion. The noncancer HI exceeded 1.0 as a result of exposure to concentrations of perchlorate in the drinking water, indicating that adverse illness could occur if complete system failure occurred. However, the estimation of exposure to these COPCs in drinking water is conservative as is the use of PHGs for estimating risk, because this risk evaluation assumes that the COPC concentration would remain constant over the entire exposure period (i.e., 56 days over 20 years) and that this water would be consumed directly without considering the mixing and dilution that would actually occur in the City of Pasadena water system. It is expected that analyte concentrations will decrease over the duration of system operation such that future exposures under subsequent failure scenarios (if failure occurs) would be to concentrations less than respective drinking water standards. Furthermore, the likelihood of complete system failure occurring is low given the automation and programming capabilities that will be used in the design of the system to prevent such failures. Therefore, the risk of injury is considered to be low, given that the likelihood of system failure is low.

7.0 Identification of Alternatives

This section presents alternatives to using treated groundwater for domestic use from: (1) the PWP wells including the Arroyo Well, Well 52, Ventura Well, and Windsor Well; (2) LAWC Wells #3 and #5; (3) Rubio Cañon Well #4. In addition, risk factors and alternative uses of the treated water are evaluated.

7.1 Alternatives to Drinking Water from the Monk Hill Subarea

The primary alternative to using groundwater extracted from production wells in the Raymond Basin, including water treated at PWP, LAWC, Rubio Cañon, and Las Flores treatment plants, is the use of imported water from the MWD of Southern California. In 2002, the 75% of the water supplied by PWP was water purchased from MWD, which consists of a blend of water from Northern California and the Colorado River. However, the U.S. Department of the Interior recently mandated that MWD reduce its allocation of water from the Colorado River to the City of Pasadena and other cities throughout the region (PWP, 2003). Because of this mandate, PWP is pursuing other long-term options for ensuring a reliable future water supply. LAWC is currently purchasing water from MWD at the maximum capacity available based on the current system design; therefore, using additional water from MWD is not an alternative option for LAWC. However, water from the FWMD may be considered an alternate water supply source for LAWC, Rubio Cañon, and Las Flores.

Other options for PWP include increasing extractions from groundwater in the Raymond Basin, maximizing the use of spreading grounds (primarily the Arroyo Seco spreading grounds located immediately adjacent to Arroyo Well and Well 52), promoting water conservation, and evaluating the feasibility of using reclaimed water. Interconnections with seven other local water systems exist; however, these are intended for emergencies, shortages, or periods of high demand.

All of the above-mentioned water purveyors have adjudicated water rights to groundwater in the Monk Hill subarea of the Raymond Basin. Six of the nine drinking water supply wells for the four water purveyors have concentrations of perchlorate above the DHS Action Level, which means that installation of new production wells within the Monk Hill subarea is not a viable alternative due to the extent of perchlorate in the subarea. Therefore, treating water from the Monk Hill Subarea is an important component of the plan for ensuring a reliable future water supply.

7.2 Evaluation of Existing Sources

Summaries of the water quality for water obtained from groundwater wells operated by PWP in 2002 (excluding the four wells in the Monk Hill subarea) and water purchased from MWD in 2002 are provided in Table 7-1. These data are compared against the projected water quality of water extracted and treated from drinking water supply wells in the Monk Hill subarea.

FMWD obtains water from the same MWD treatment plant as PWP; therefore a separate analysis of FMWD water as an alternate source was not completed.

7.2.1 Comparison to Existing Sources

PWP tests its water (extracted from production wells located outside the Monk Hill subarea) regularly for organic chemicals, minerals, metals, bacteria, and total trihalomethanes using DHS-approved methods. Table 7-1 provides summaries of constituents detected in PWP drinking water that have federal and state drinking water standards. More than 100 regulated constituents and other constituents of interest have been tested but were not detected in water delivered by PWP (2003). Constituents that were not detected are not included in the table.

For both PWP and MWD, naturally occurring inorganic constituents and radionuclides were detected at levels less than drinking water standards. Perchlorate was detected occasionally in PWP water at a concentration equal to the DHS Action Level of 6 ppb, but the overall average concentration of perchlorate was below analytical detection limits; no perchlorate was detected in MWD water in 2002. Overall, no chemical constituents or water quality parameters were detected above respective drinking water standards in PWP water or MWD water for the year 2002. Based on this comparison to drinking water standards, water obtained from PWP and MWD would not be associated with adverse health effects.

The proposed treatment systems are designed to reduce carbon tetrachloride, tetrachloroethene, 1,2,3-TCP, and/or perchlorate concentrations to below their respective regulatory limits. Therefore, based on comparison to drinking water standards, water extracted and treated from the Monk Hill subarea would not be associated with adverse health effects and would be of comparable quality to water from PWP production wells located outside the Monk Hill subarea, MWD, and FWMD.

7.2.2 Assurance of Supply

Rainfall is the main source of water that replenishes the Raymond Basin. The adjudicated water rights of PWP and other water agencies are intended to equal the water naturally replenished by the rain. However, during a drought and normal pumping, groundwater levels may drop. Nonetheless, the water rights in the Raymond Basin were established by court order in 1944 and will remain in place.

PWP

Currently, groundwater from five active wells is directed to 18 reservoirs located throughout the city (11 wells are inactive due to the presence of perchlorate). Jones Reservoir is the largest and can hold up to 50 million gallons of water. The smallest reservoir, the Lida Reservoir, holds up to 0.43 million gallons of water. These reservoirs provide a total of 110 million gallons of water, which could provide potable water for approximately 3.5 days (personal communication with PWP). However, the city has a total of 27 interconnections with seven other local water systems that can supply water during emergencies, shortages, or periods of high demand, so it is unlikely that total water system failure would occur.

LAWC

Groundwater from two active wells is directed to 11 reservoirs located throughout the service area. South Glenrose is the largest and can hold up to 2.72 million gallons of water. The smallest reservoir is the Olive Avenue Sump, which can hold up to 200,000 gallons of water. These reservoirs provide a total of approximately 10 million gallons of water. LAWC also has a series of three connections, two with PWP and one with Las Flores, which can supply water during emergencies, shortages, or periods of high demand, so it is unlikely that total water system failure would occur.

Las Flores

Groundwater from one active well is directed to 5 reservoirs located throughout the service area. The Blending Sump is the smallest reservoir and can hold up to 33,000 gallons. The Cobb Reservoir is the largest reservoir and can hold up to 1.5 million gallons of water. Las Flores has a total reservoir capacity of 4.73 million gallons of water, and also maintains an emergency connection with LAWC, so it is unlikely that total water system failure would occur.

Rubio Cañon

There are 8 reservoirs located throughout the Rubio Cañon service area, including two Calaveras Tanks (506,000 gal each), three Maiden Lane Tanks (614,250 gal, 944,250 gal, and 1,770,000 gal), the Canon Reservoir (3,420,000 gal), and two Zane Grey Tanks (25,000 gal each). Rubio Cañon has a total reservoir capacity of 7.8 million gallons of water, and also maintains an emergency connection with PWP, so it is unlikely that total water system failure would occur.

MWD

MWD is undergoing regulatory constraints with regard to the use of Colorado River water, and is actively pursuing alternative options to ensure future water supply. In March 2003, a report was developed by MWD entitled, "Report on Metropolitan's Water Supplies" in compliance with SB 221 and SB 610 (MWD, 2003). These new laws require water districts to develop and publish information on available and planned future water supplies in order to assist local public agencies making land use decisions. As described in this report, MWD and its member agencies have developed contingency supply sources to protect the reliability of the system. As a result of the reduced supply of Colorado River water, MWD has been maximizing storage and water transfer options and today has more than two million acre-feet of water in storage and intends to purchase up to 250,000 acre-feet of additional short-term water supplies. Long-term plans to meet reliability needs through water transfer programs, outdoor conservation measures, and development of additional local resources, such as recycling, brackish water desalination, and seawater desalination, have been expedited.

7.2.3 Interruptions to Service

PWP, LAWC, Las Flores and Rubio Cañon have instituted the following measures to help avoid interruptions to service:

- ❑ The water supply systems are equipped with Supervisory Control and Data Acquisition (SCADA) systems to monitor each of the distribution systems. The SCADA systems allow the recognition of interruptions and/or failures to be identified much sooner than without the system. Interruptions of service could result if any infrastructural damage occurs as a result of natural factors (i.e.,

general wear and tear of system, earthquakes, and fires) or artificial factors (i.e., construction activities).

- ❑ The companies implement facilities maintenance programs for the water system mechanical equipment which enhances distribution system reliability and reduce power costs.
- ❑ Each water company has established and maintains partnerships with neighboring water agencies to provide water utility related services.
- ❑ PWP is also continuing to upgrade and replace old water mains for improved fire protection capability and system integrity.

The water that MWD imports from the Colorado River is transported via the 242-mile Colorado River Aqueduct. The aqueduct travels through the Mojave Desert and travels through mountains, five pumping plants, and 92 miles of tunnels. Water from MWD that originates in Northern California is transported in the State Water Project's 444-mile California Aqueduct. Service may be interrupted if infrastructural damage occurs as a result of natural or artificial factors. The treated water obtained during operation of the drinking water production wells would reduce the potential for service interruptions, thereby increasing the safety of citizens of Pasadena during emergencies such as fires and earthquakes.

7.3 Evaluation of Disposal Alternatives

Groundwater extracted from the public drinking water supply wells will be treated and used for domestic purposes throughout the service areas of the four public water purveyors. As such, extracted groundwater will not be disposed of under this proposed plan. However, in the absence of operating the drinking water supply wells with centralized treatment, additional measures would be required by NASA at the JPL site to contain the existing perchlorate plume as part of a CERCLA removal action to prevent migration of chemicals of interest. Under this scenario, water extracted from groundwater remediation wells in the Monk Hill Subarea would need to be disposed of following treatment. Several options were evaluated by NASA with respect to site-specific conditions, including:

- ❑ Use as drinking water (centralized treatment)
- ❑ Return to the aquifer via reinjection
- ❑ Return to the aquifer via infiltration (i.e., Arroyo Seco spreading grounds)
- ❑ Supply as irrigation water
- ❑ Discharge to publicly owned treatment works (sanitary sewers)
- ❑ Discharge to drainage channels.

NASA does not have water rights in the Raymond Basin; therefore, it is preferred that the groundwater extracted for this removal action either is provided to a party with water rights (e.g., City of Pasadena) or is reintroduced to the aquifer to replace the extracted groundwater. The options of discharging the water to a publicly owned treatment works or drainage channels were eliminated from further consideration, due to the quantity of water that would be extracted. The option of using treated water for irrigation was eliminated from further consideration, due to the complexity of implementation and high costs (including the need for

extensive water rights agreements, separate conveyance system or reservoir, and finding uses for the large quantity of water that would be generated year round).

7.3.1 Arroyo Seco Spreading Grounds

Discharge to the Arroyo Seco spreading grounds is a potentially viable end-use option for water. The Arroyo Seco spreading grounds are located between the JPL facility and the production wells and PWP has used the Arroyo Seco Basins to spread more than 20 cfs over an extended period of time. However, it was determined that this option was not preferable over the long-term, for the following reasons:

- ❑ The expansion of the spreading grounds beyond their current areas could adversely impact the containment effectiveness of the removal action, because the spreading grounds are located between the JPL facility and the production wells.
- ❑ Under the Raymond Basin adjudication, infiltration basins do not get full credit for the volume of water that is applied (i.e., 80% spreading credit). This means that water rights would have to be negotiated for 20% of the extracted water.

However, as a temporary end-use option, the existing spreading basins could be used for disposal of the treated groundwater. The estimated volume of water that could be discharged to the spreading basins is 470 acre-feet per month (assuming a 3,500 gpm flowrate). This volume could be handled by the basins on a short-term basis under typical conditions.

7.3.2 ReInjection of Treated Water

Reinjection of treated water appears to be a technically viable alternative. Adequate plume containment could be attained by extracting approximately 3,000 gpm of groundwater, and possibly less. The treated water would be pumped to a group of injection wells inside the western boundary of the JPL facility.

7.4 Conclusions and Recommendations

Information provided in this section focuses on the identification of alternate sources to the impaired drinking water source. Also presented in this section was information regarding alternatives for disposal of the extracted groundwater. A summary of the conclusions and recommendations for the alternative assessment is as follows:

- ❑ MWD and FMWD are the primary alternative sources of drinking water for the City of Pasadena, Lincoln Avenue Water Company, Las Flores Water Company, and Rubio Cañon Land and Water Company.
- ❑ The U.S. Department of the Interior recently mandated that MWD reduce its allocation of water from the Colorado River to the City of Pasadena and other cities throughout the region; therefore, maximizing use of water rights in the Raymond

Basin via production wells is an important component of ensuring reliable future water supply to customers.

- ❑ Treated groundwater from the Monk Hill subarea would provide water of comparable quality as that provided by production wells located outside the Monk Hill subarea and MWD, based on 2002 data.
- ❑ The treated water obtained during extraction from wells in the Monk Hill subarea would provide additional local service and reduce the potential for service interruptions, thereby increasing the safety of citizens of Altadena and Pasadena during emergencies such as fires and earthquakes.
- ❑ Based on the evaluation of alternatives, it is recommended that treated groundwater from the Monk Hill subarea be used to supplement other drinking water sources.

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